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MEMORANDUM REPORT ARBRL-MR-03275

COPPERHEAD BATTERY TESTER

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US ARMY ARMAMENT RESEARCH AND DEVELOPMENT COMMAND
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The development of a tester for the control section battery of the M712 Cannon-Launched Guided Projectile has fulfilled a requirement for the automatic testing of a series of batteries. The tester is a self-contained instrument that is used with a shock test system to rapidly perform complete tests after an initial setup.

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I. INTRODUCTION

During the development of the M712 Cannon-Launched Guided Projectile or COPPERHEAD Guided Projectile, a requirement arose for the testing of the thermal battery that is a primary component of the control section. This battery provides power output at +11, +30, and -30-volts direct current. Its physical size is 1.90 inches (4.83 cm.) diameter by 8.83 inches (22.43 cm.) long. The electrical interface to the battery is made through solder terminals located at each end. The +11-volt section is activated by an inertial starter mechanism and the ± 30-volt sections are activated by an electrical initiator or "match."

The COPPERHEAD Battery Tester is a self-contained instrument that is used with a Shock Test System to perform complete tests on the COPPERHEAD battery. It contains all of the timing circuits, constant current load circuits, calibration circuits, monitoring circuits, and fixed resistive loads for performing the tests. Ten output jacks are provided for recording voltage, current, and noise data. A high input impedance (greater than 20K ohms) recorder should be used. Automatic calibration is provided on each output prior to the test. Automatic actuation of the Shock Test System is also provided. In addition, an elapsed timer is provided as a convenience for visually monitoring the time of all functions. These automatic features permit the rapid testing of a series of batteries after the initial setup has been performed. An overall block diagram of the Battery Tester with a test battery is shown in Figure 1. This equipment is designed to provide the test requirements as stated in MIL-P-63235 (AR).

II. DESCRIPTION

A. Description of Timing Circuits

1. 11-Volt Timer. The function of this unit is to start the timed load sequencing for the complete battery and control the application of the timed loads for the 11-volt section. Reference is made to Figures 2 and 3. As seen in Figure 2, a comparator is used to initiate the timing sequence. After the 11-volt section is shock initiated, a rise in its output voltage triggers the comparator to the "ON" state when this voltage exceeds a 10-volt reference level. The output of the comparator turns on a 100-second timer that is used as a lockout device to prevent any additional false triggers during the 100-second time period of the test. When this lockout timer is triggered, all of the timers following the inverters are triggered. This includes the timers in the 30-volt unit.

The first timer following the lockout device applies a 31-ohm squib load for a period of 20 milliseconds, and starts the elapsed timer on the front panel of the tester. The second timer is turned on for 210 milliseconds and at the end of this period, a voltage is applied to the battery "MATCH" terminals for a period of 20 milliseconds. This match function initiates the ± 30-volt section of the battery. At the end of this function a 100-second timer is turned on. This timer connects the "MATCH" terminals to the ± 30-volt common terminal through a current shunt so that any leakage current present may be monitored. The last two timers are turned on for periods of 1.5 seconds and 45 seconds. At the end of these two periods, a 1.3-ohm squib load is applied for a period of 20 milliseconds.

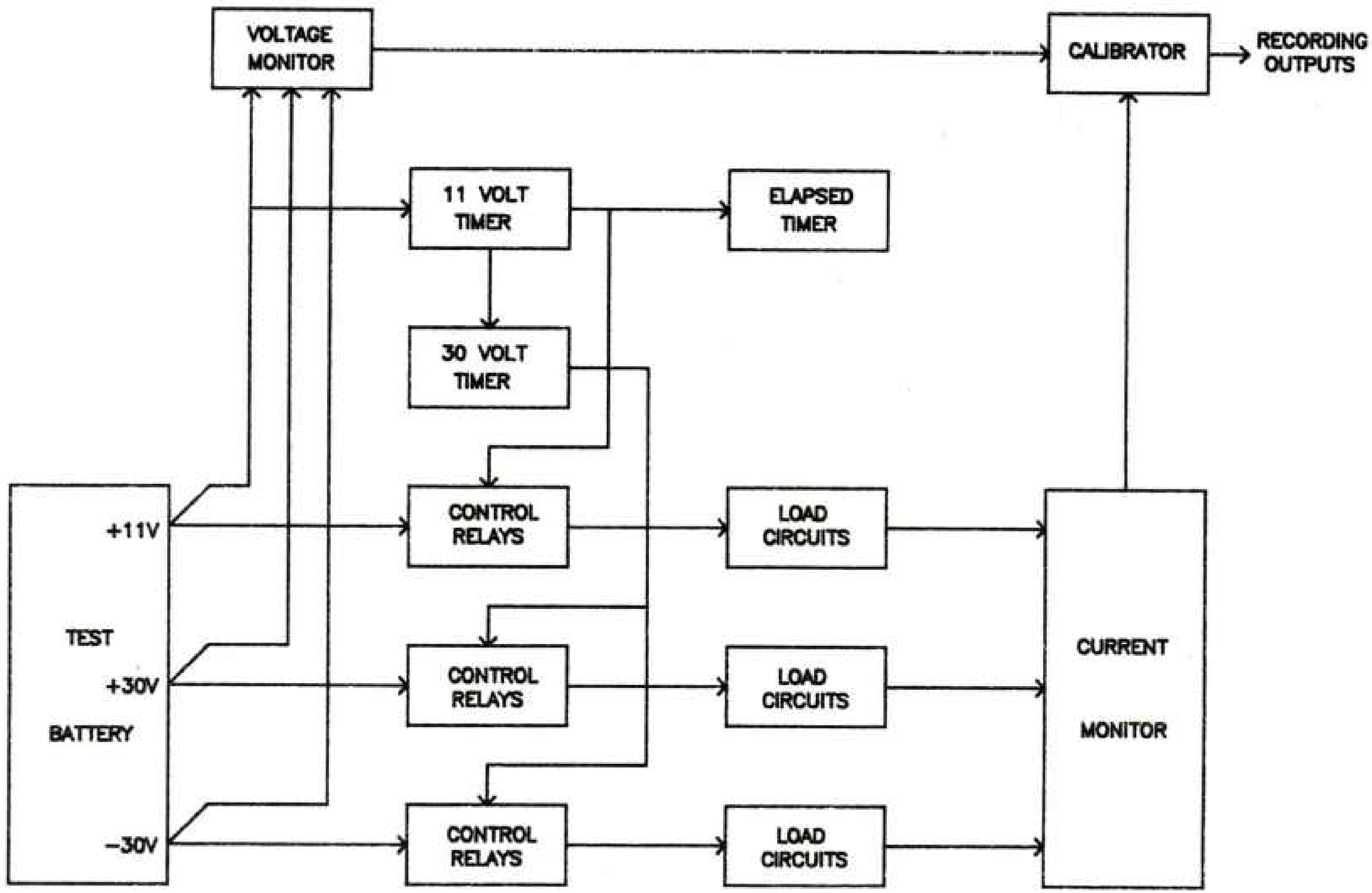


Figure 1. Battery Tester Block Diagram

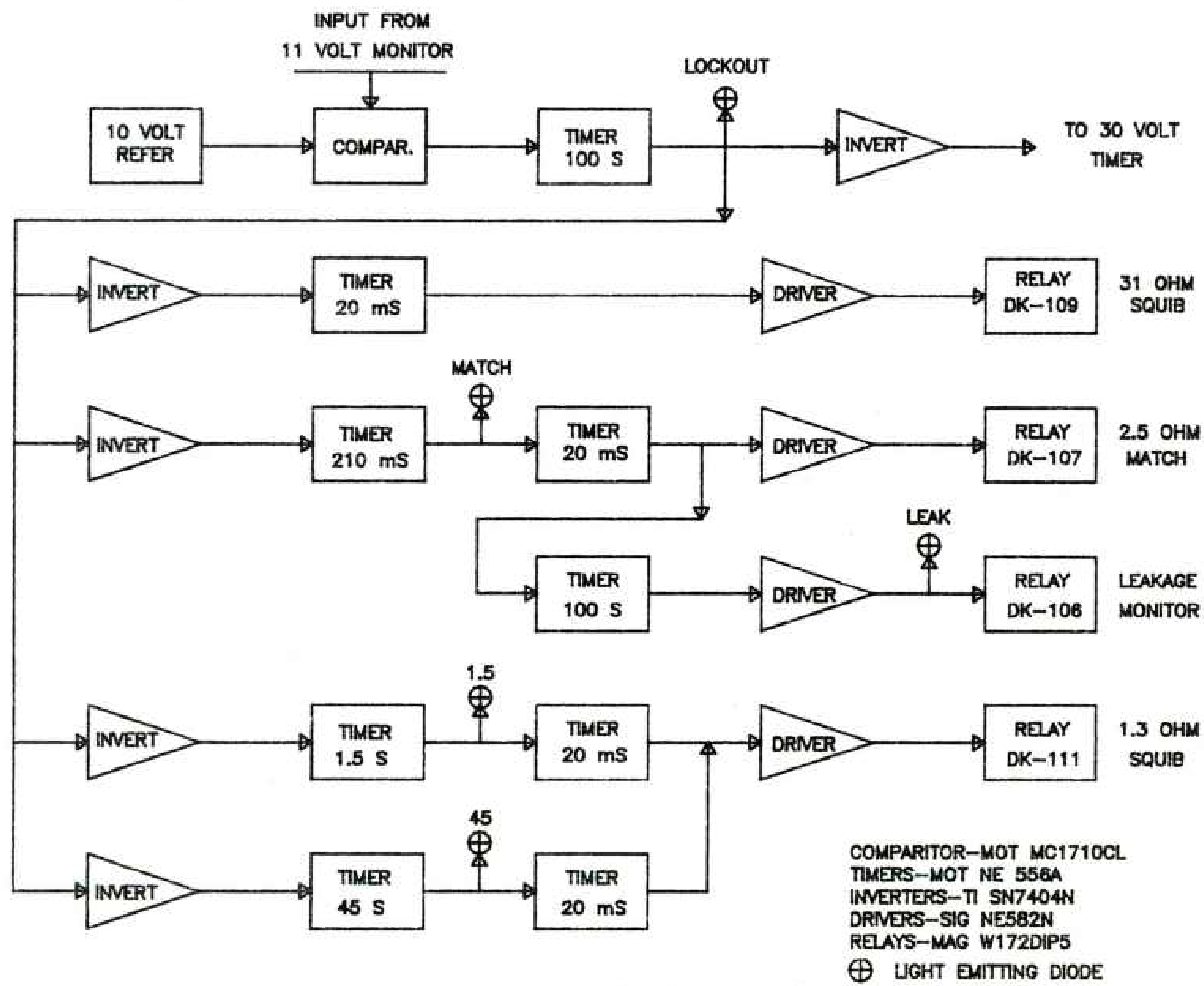


Figure 2. 11-Volt Timing Logic

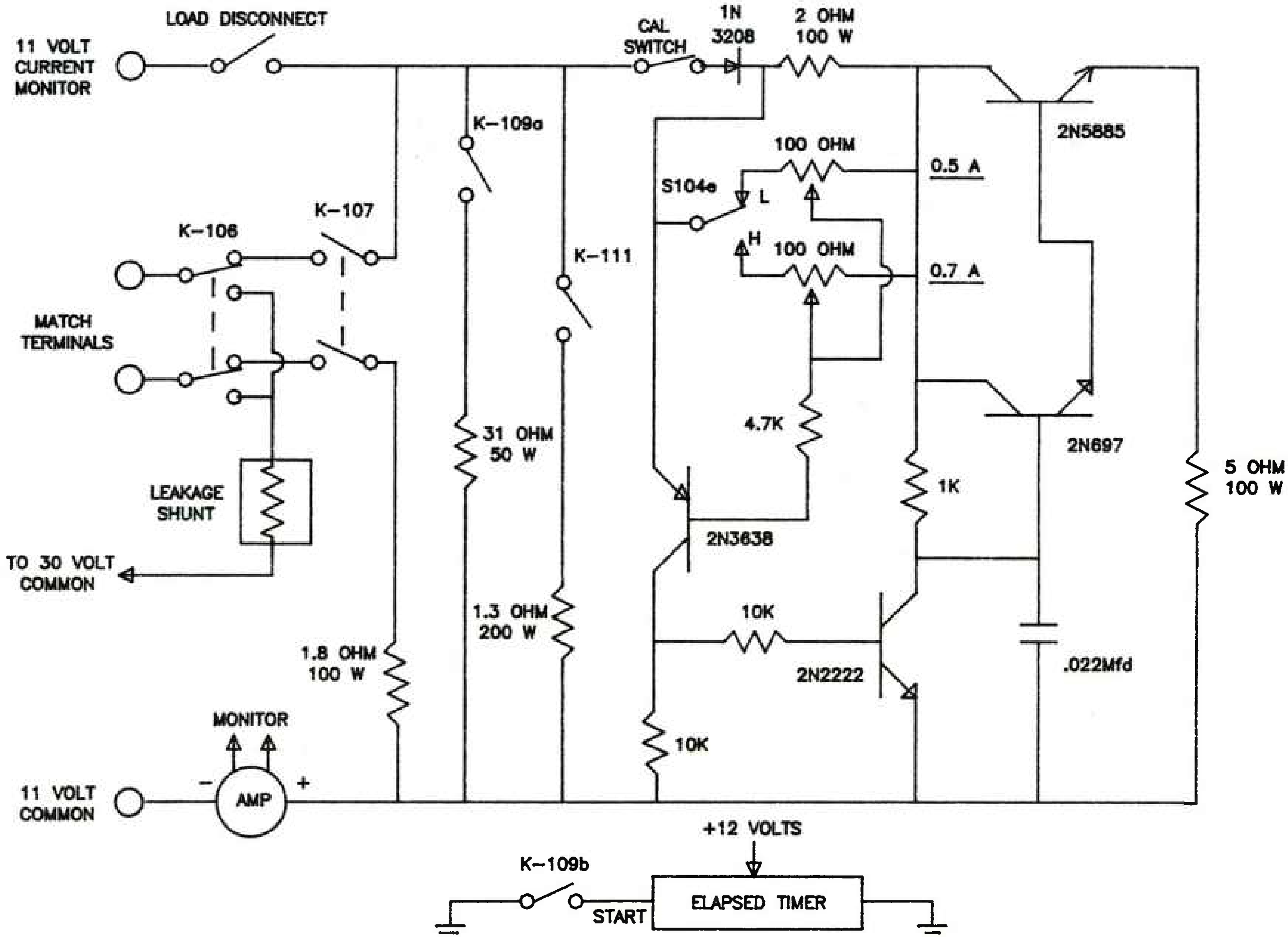


Figure 3. 11-Volt Load Circuits

2. ± 30-Volt Timer. The function of this unit is to control the application of the timed loads for the +30-volt and -30-volt sections of the battery. Reference is made to Figures 4, 5 and 6. The first group of 4 timers is used to apply a 4.75-ohm squib load to the +30-volt section of the battery at 1, 2, 3, 4 and 5 seconds for a period of 20 milliseconds. The 4.2-second timer and the first 0.5-second timer are triggered simultaneously. After triggering the gate relay is closed allowing both 0.5-second timers to trigger each other. The squib load is applied at the end of each period of the right-hand 0.5-second timer. The gate relay is opened at 4.2 seconds to prevent further application of the load after 5 seconds. A constant current load change from 1.2 amperes to 4.0 amperes is made on both 30-volt sections at the end of the period of the 5.2-second timer. The 64.8-second timer keeps relay K-102 closed until the end of the test period (70 seconds). Another load change from 4.0 amperes to 1.9 amperes is made at the end of the 10-second timer period. The 60-second timer keeps relay K-103 closed until the end of the test. The last group of 6 timers applies a 4.0-ampere squib load to both 30-volt sections for a period of 0.5 second at 29.5, 39.5 and 49.5 seconds.

B. Description of Calibrator and Recording Circuits

The purpose of this unit is to initiate the test sequence, calibrate all recording channels, provide a contact closure for triggering a shock table, and condition all monitor outputs for recording. Reference is made to Figure 7.

1. Calibrator and Shock Table Trigger. The test sequence is started by depressing the "START" switch which turns on the first timer for 50 milliseconds or 500 milliseconds (selectable by internal switch). The relays controlled by this timer transfer all recording outputs from the monitor inputs to calibrated voltage sources for the length of the timer period. At the end of this period a 20-millisecond timer is triggered and the shock table relay is actuated. All calibration voltages are derived directly from a direct current (DC) source or thru an attenuator from a DC source. The voltages at the recording outputs are adjusted for a total span of 2.6 volts (i.e. + 2.6, - 2.6, or ± 1.3 volts) to be compatible with the standard input range of a tape recorder.

2. Recording Circuits. Battery voltages are recorded directly through attenuators to be compatible with the tape recorder. Current is monitored from the voltage developed across the terminals of the front panel ammeters. This voltage is amplified so that 2.6 volts at the recording output is equivalent to 10 amperes. Battery noise is monitored by capacity coupling from each battery voltage monitor terminal to an amplifier. The amplifier output voltage is adjusted so that 420 millivolts peak-to-peak on the input is equivalent to ± 1.3 volts DC on the output. The input to each amplifier is protected from voltage transients by the use of clamping diodes that limit the input voltage to ± 0.7 volt peak-to-peak.

An output voltage from a DC source is provided for calibrating a charge amplifier used for shock table acceleration measurements. This output voltage can be adjusted from 0 to - 12 volts by means of a front panel mounted potentiometer.

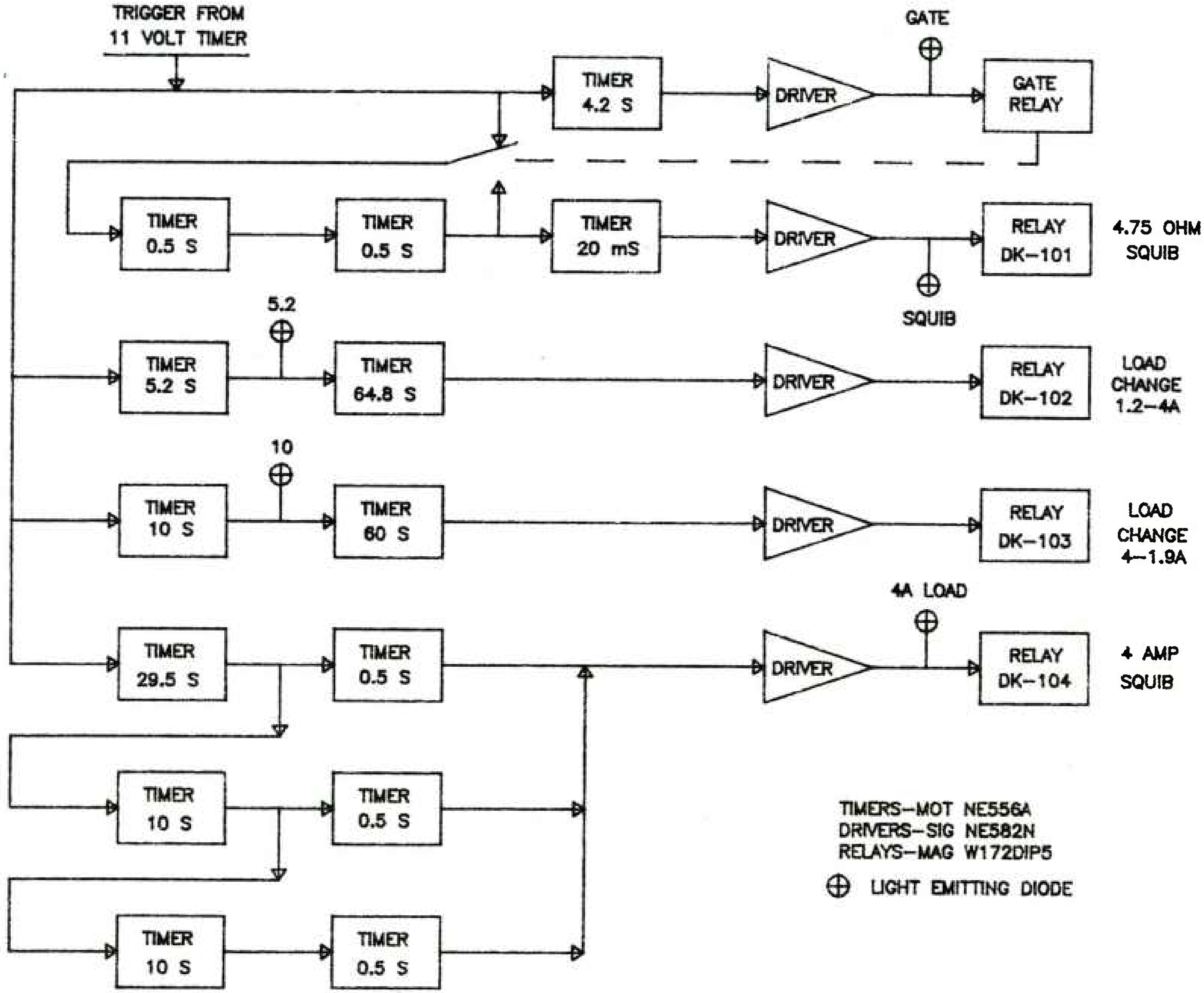


Figure 4. 30-Volt Timing Logic

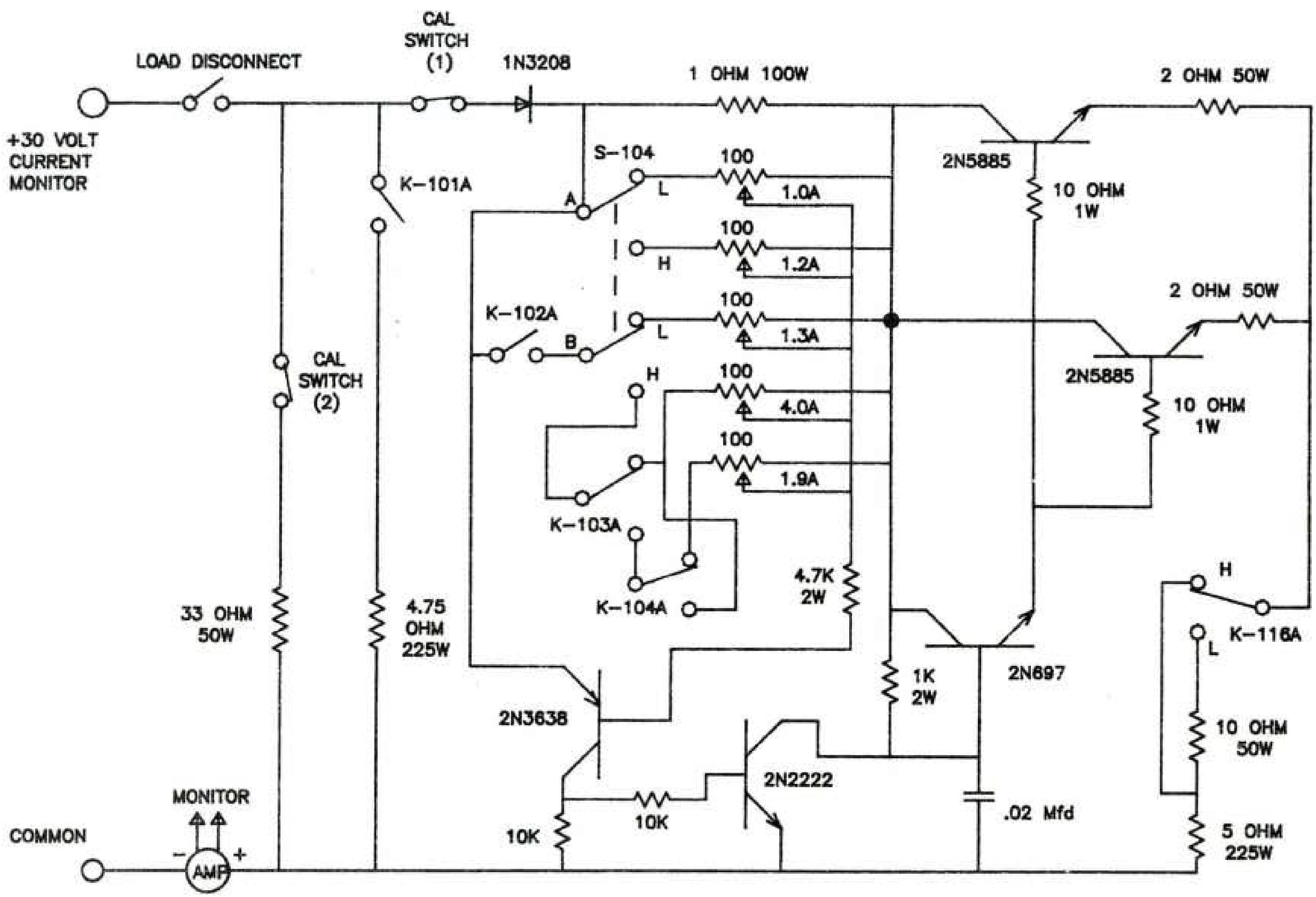


Figure 5. +30-Volt Load Circuits

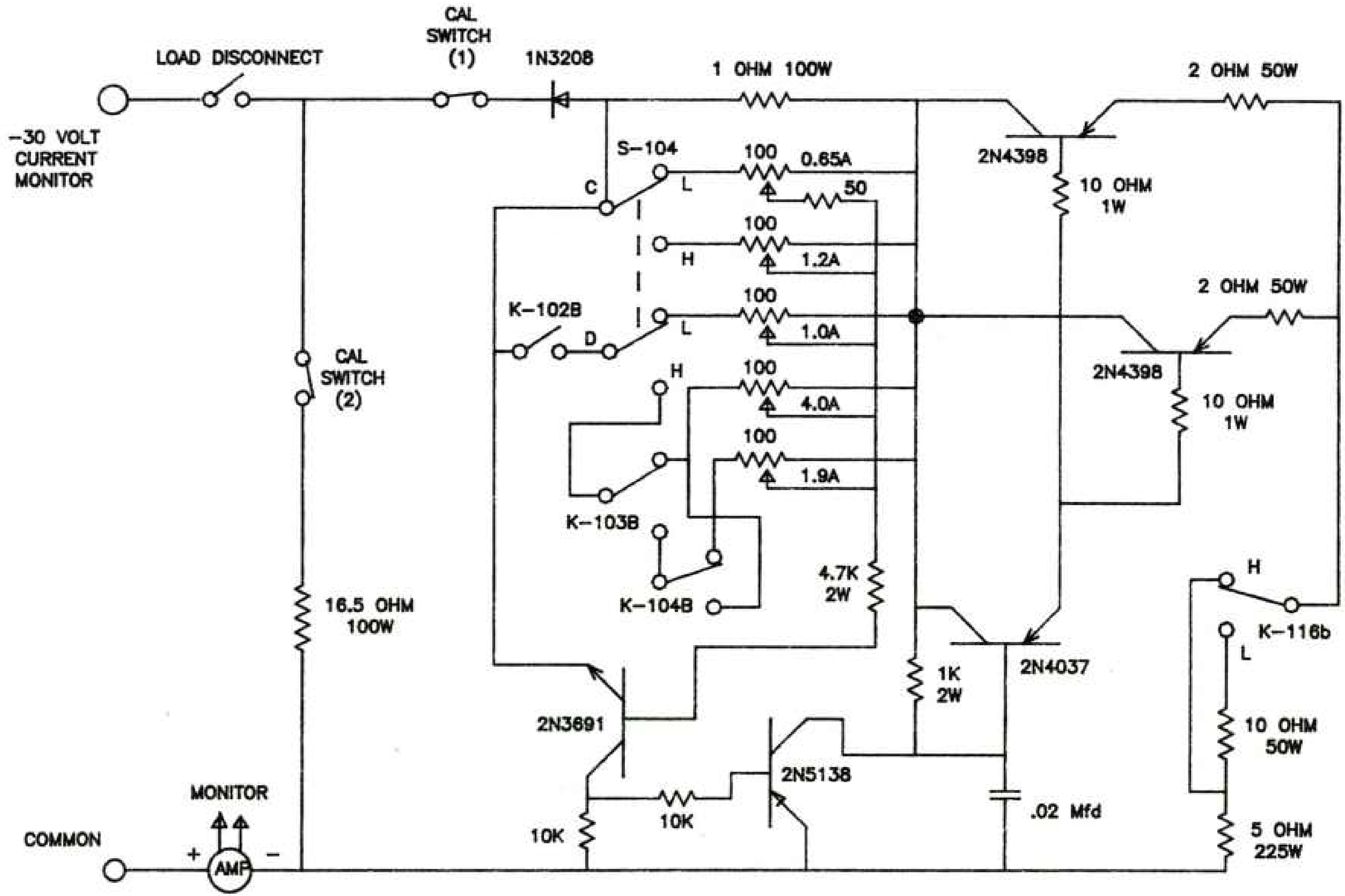


Figure 6. -30-Volt Load Circuits

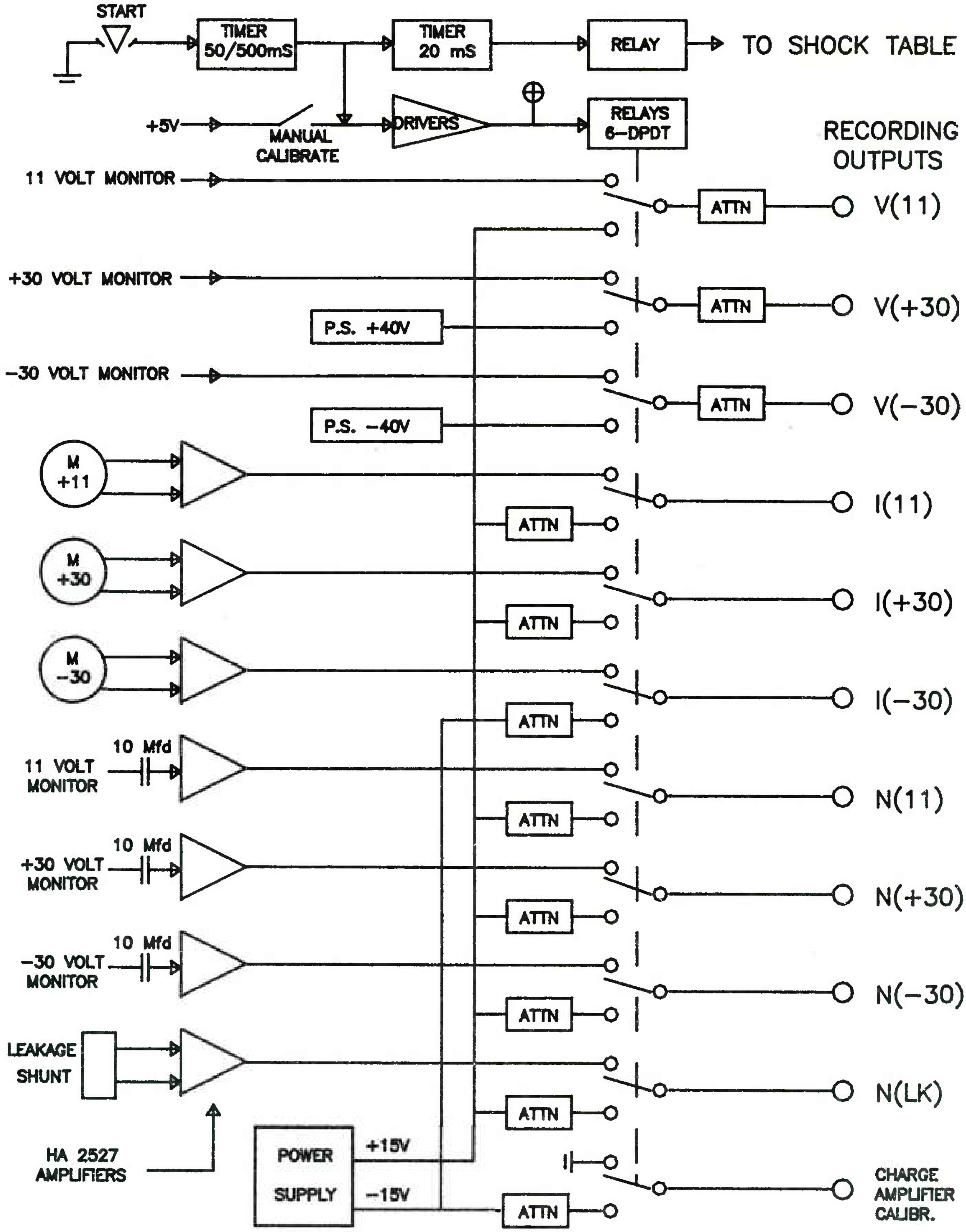


Figure 7. Calibrator

The "MAN CAL" switch, on the front panel, is used to actuate all calibration relays so that adjustments can be made on calibration voltage outputs.

C. Constant Current Circuits

The constant current circuits are used to provide various constant loads to all sections of the battery during the test period. Schematics of these circuits are shown in Figures 3, 5 and 6. The various loads are switched in and out by the timers. These circuits are located on the large rear panel with all current adjusting potentiometers and calibration switches as shown in Figure 8. A set of 5 switches that is used for manually energizing the power relays is located near the bottom of this panel. A "LOAD CHANGE" switch with appropriate red and green indicator lamps is located on the front panel as shown in Figure 9. This high-low load switch is used to change the configuration of the constant current loads applied to the battery during a particular test. When operating in the high load mode, all load change functions are applied to the battery. The following changes are made when a test is made in the low load mode:

- 11-Volt Section: The constant current load is 0.5 ampere instead of 0.7 ampere.
- \+ 30-Volt Section: The initial constant current load is 1.0 ampere instead of 1.2 amperes; the load is changed to 1.3 amperes instead of 4.0 amperes at 5.2 seconds; and the load changes at 10, 29.5, 39.5, and 49.5 seconds are eliminated.
- \- 30-Volt Section: The initial constant current load is 0.65 ampere instead of 1.2 amperes; the load is changed to 1.0 ampere instead of 4.0 amperes at 5.2 seconds; and the load changes at 10, 29.5, 39.5, and 49.5 seconds are eliminated.

The complete operation of these circuits is explained in the setup procedure.

D. Load Resistors and Power Supplies

All load power resistors are contained in a pullout drawer located below the timing chassis. This layout is shown in Figure 10. This drawer also contains a 24-volt power supply to operate the power relays and a regulator circuit to provide 12-volt power to the elapsed timer. The elapsed timer circuit is shown in Figure 11.

E. Test Connections

Figure 12 shows a block diagram of the external test connections between the tester, battery, shock table, accelerometer, and charge amplifier. Separate voltage monitor leads are connected at the battery so true readings of the actual battery voltage can be made. The accelerometer set up shown is for a charge mode type of transducer. Figure 13 shows the time and load profile for each section of the test battery.

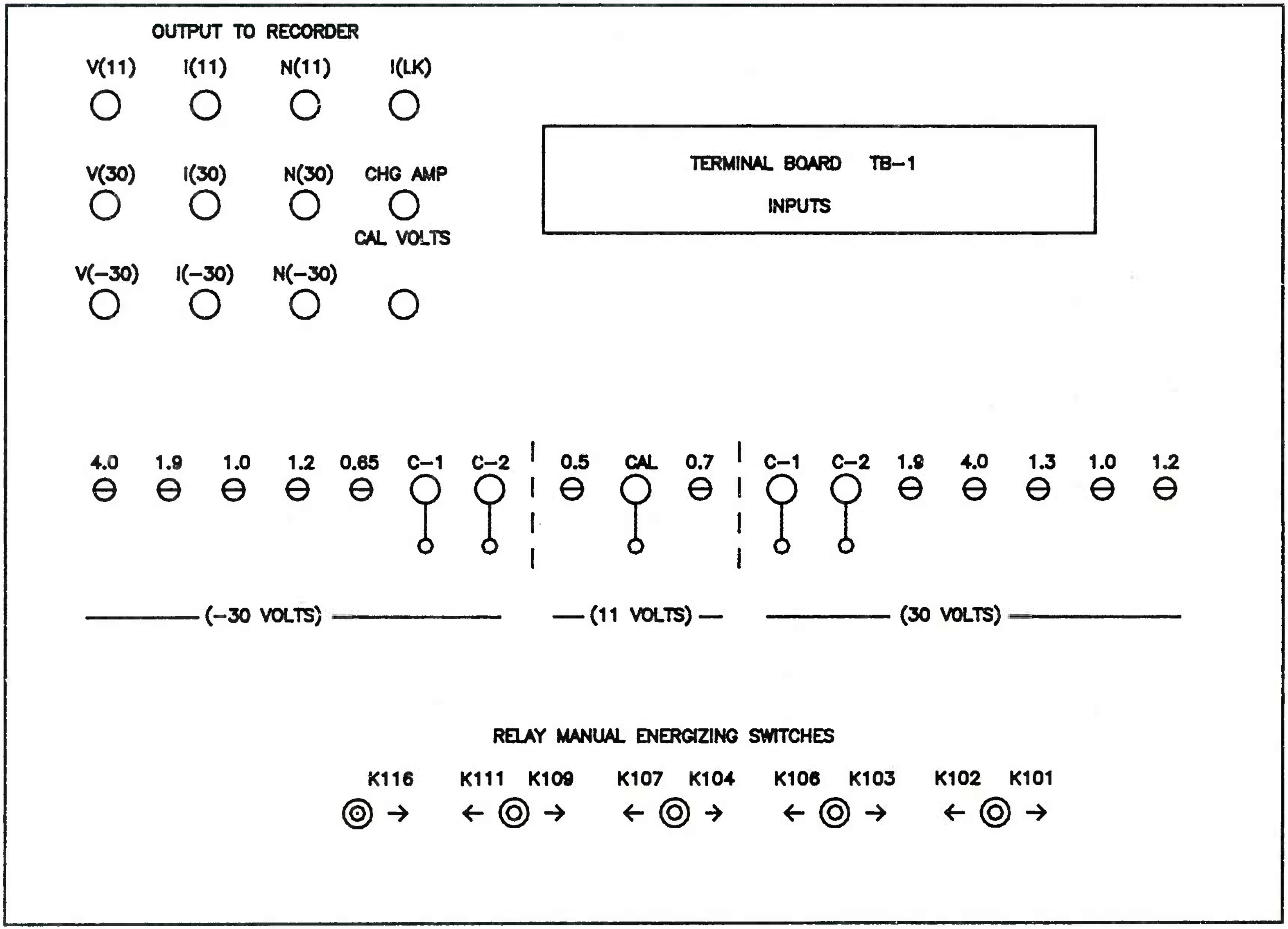


Figure 8. Battery Tester Rear Panel

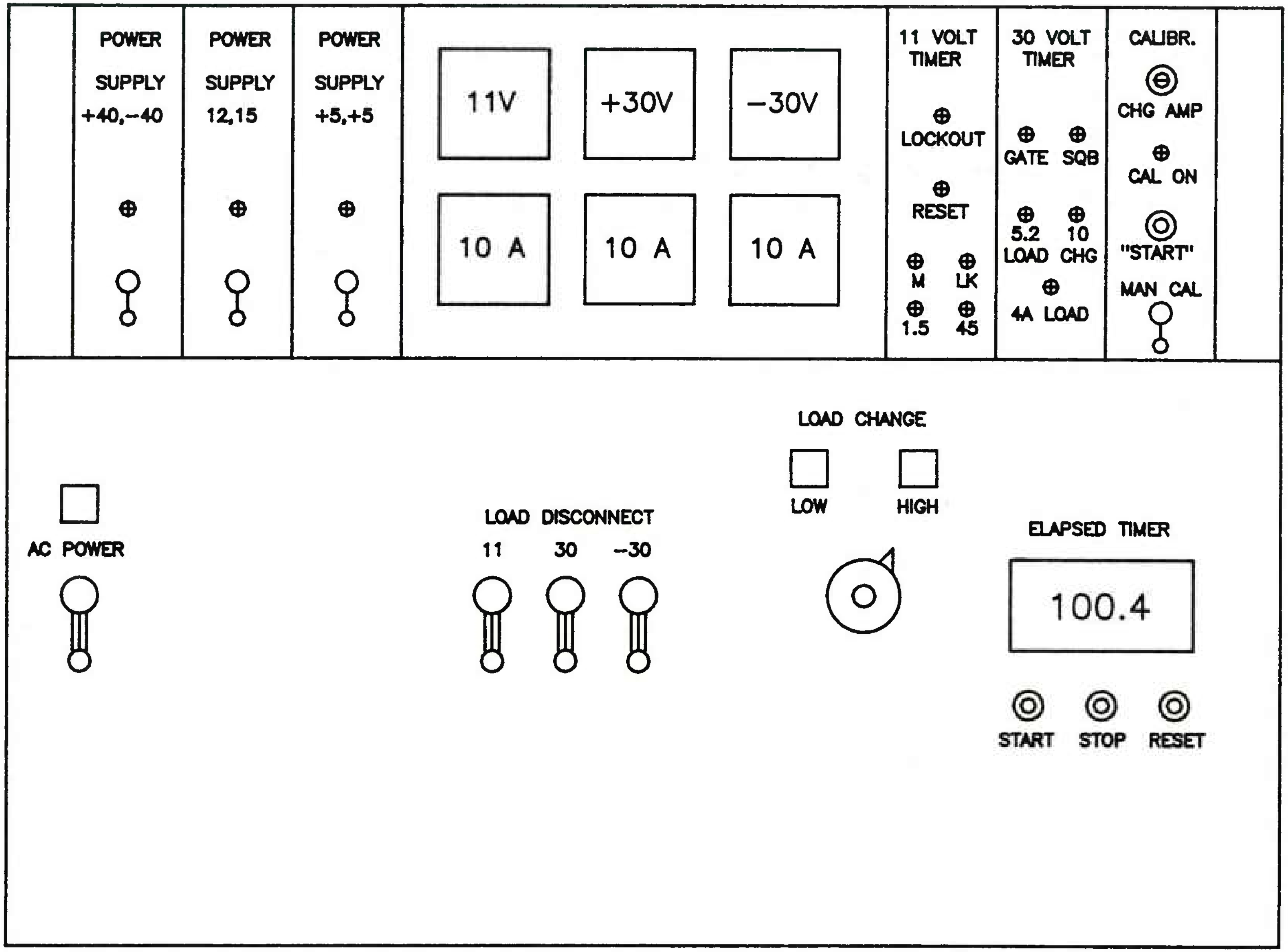


Figure 9. Battery Tester Front Panel

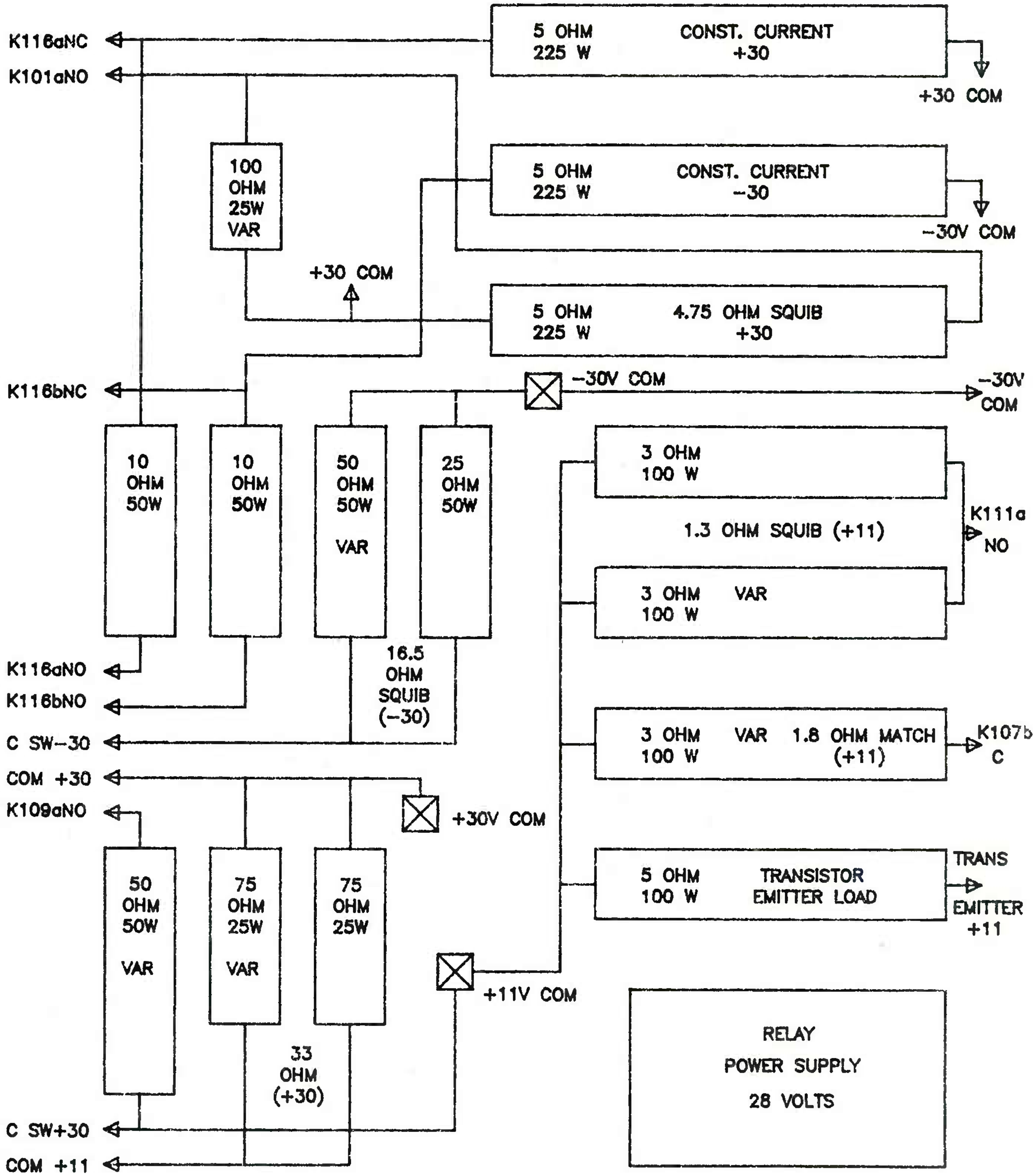


Figure 10. Power Resistor Block Diagram

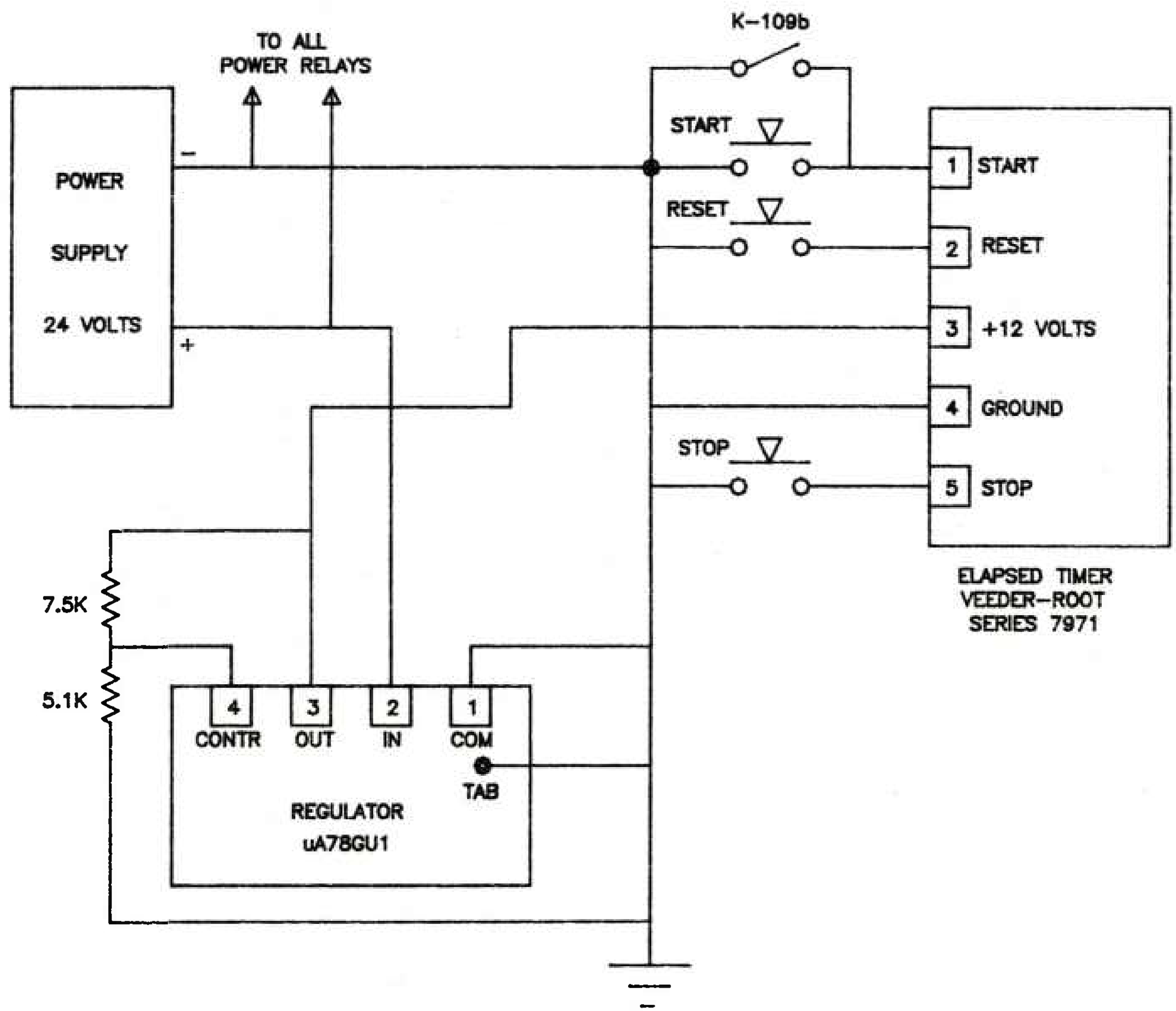


Figure 11. Elapsed Timer Circuit

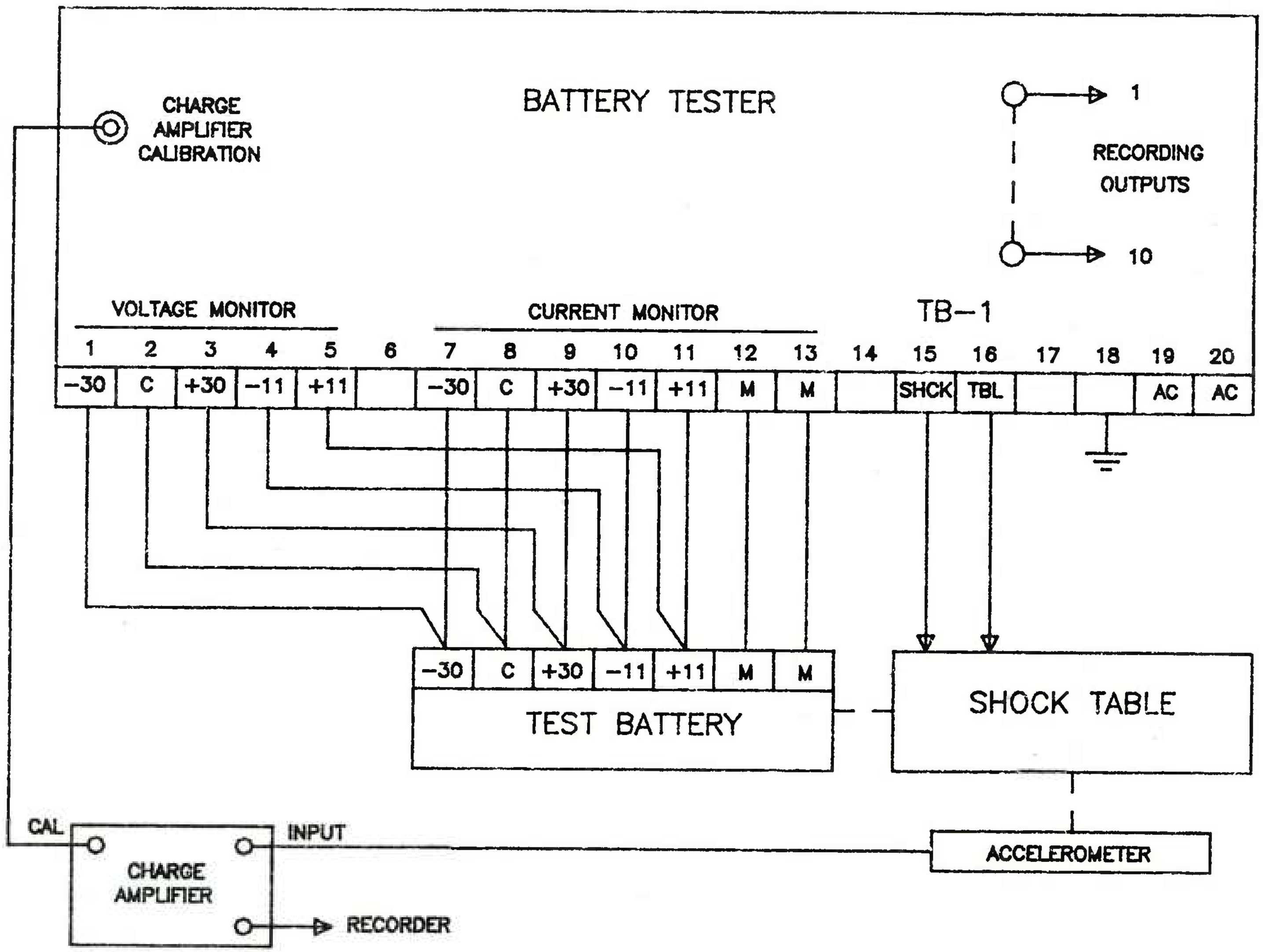


Figure 12. External Test Connections

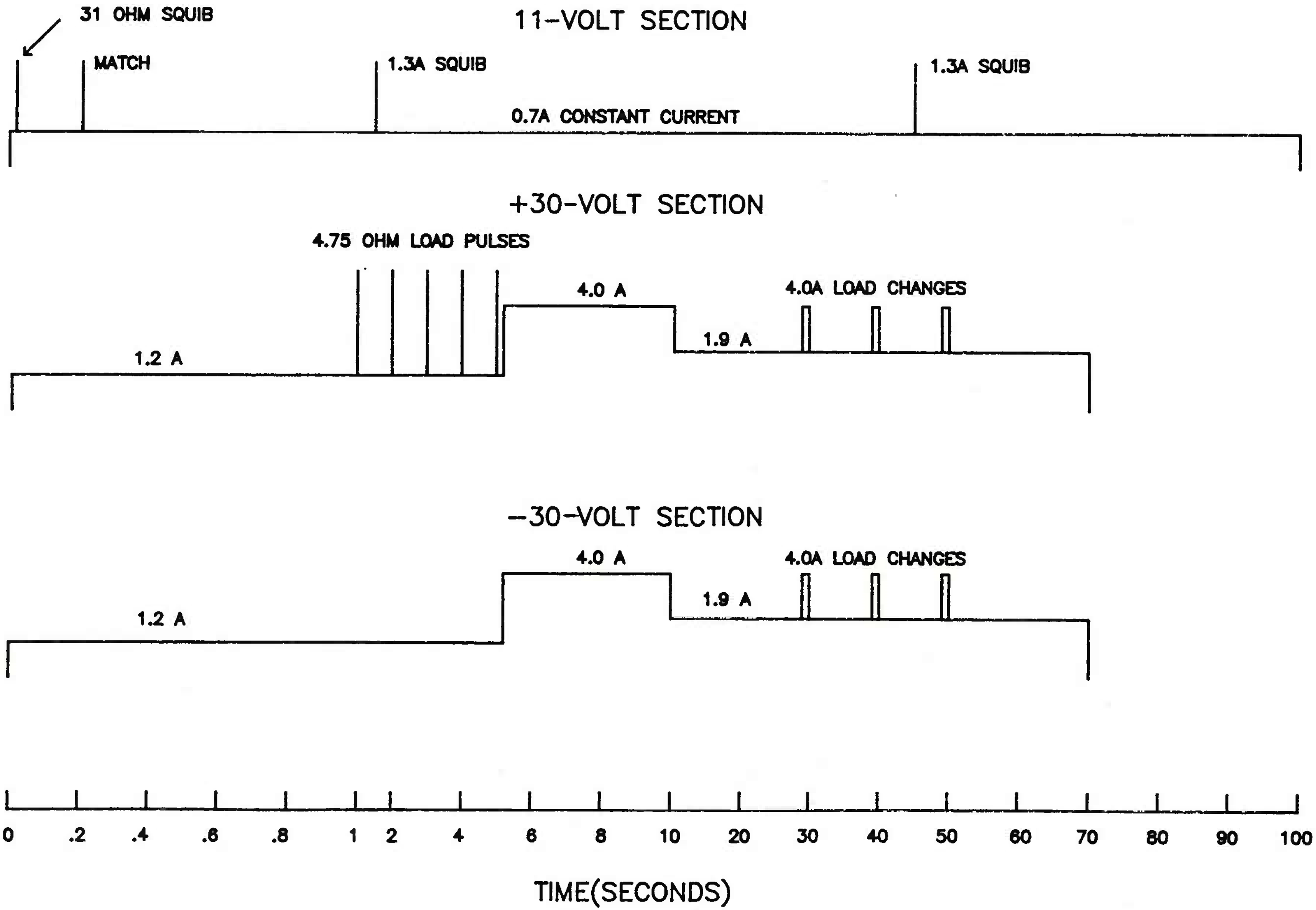


Figure 13. Battery Load Profiles

III. SETUP PROCEDURES

The tests for this procedure are made with the following list of equipment where typical types of equipment and source or measurement ranges are specified:

- o Direct current power supply, Hewlett-Packard Model 6274B, 0 to 50 volts at 8 amperes.

- o Digital Multimeter, Hewlett-Packard Model 3466A, 0 to 50 volts with a resolution of 0.1 volt, 1 to 40 ohms with a resolution of 0.01 ohm.

- o Direct Current Shunt, Fluke Model 80J-10, 0 to 10 Amperes (To be used with a digital multimeter).

- o Function Generator, Tektronix Model FG-502, 0 to 0.5 volt Peak-to-Peak at 500 Hz.

The source is connected to the rear voltage or current monitor input terminals with the proper polarity. Current measurements are made with an external ammeter, and voltage measurements are made at the appropriate rear British National Connector (BNC) type jacks with the recording device connected. Adjustment potentiometers are provided on the rear panel for any measurements that do not fall within range. Reference is made to Figures 8 and 9 for the location of all adjusting potentiometers and switches. After this setup procedure has been performed, tests can be made quite rapidly on a series of batteries.

A. Constant Current Loads

These tests are made with the direct current power supply and ammeter connected to the rear current monitor terminals. The power relays are energized manually by toggle switches located at the bottom of the rear panel. (See Figure 8.) These switches have a center off position and a relay is energized by moving the switch to the right or left. The measured values of current should be within ± 3% of the underlined values.

1. <u>11-Volt Section</u>. Measurements are made with an input of 11.5 volts and 15 volts.

   a. Position the following switches:

      "11-VOLT CAL" - down
      "11-VOLT LOAD DISCONNECT" - up

   b. Measure <u>0.5 ampere</u> with "LOAD CHANGE" switch on low.
   c. Measure <u>0.7 ampere</u> with "LOAD CHANGE" switch on high.
   d. Position "11 LOAD DISCONNECT" switch down.

2. <u>+ 30-Volt Section</u>. Measurements are made with an input of 26 volts and 36 volts.

   a. Position the following switches:

"+ 30-VOLT C-1" - down
"+ 30-VOLT C-2" - up
"+ 30 LOAD DISCONNECT" - up
"LOAD CHANGE" switch - high

b. Measure 1.2 amperes

c. Energize "K102," measure 4.0 amperes

d. Energize "K103," measure 1.9 amperes

e. Energize "K104," measure 4.0 amperes

f. De-energize all relays

g. Position "LOAD CHANGE" switch - Low

h. Measure 1.0 amperes

i. Energize "K102," measure 1.3 amperes

j. De-energize "K102"

k. Position "LOAD DISCONNECT" - down

3. - 30-Volt Section. Measurements are made with an input of -26 volts and - 36 volts.

a. Position the following switches:

"- 30-VOLT C-1" - down
"- 30-VOLT C-2" - up
"- 30 LOAD DISCONNECT" - up
"LOAD CHANGE" switch - high

b. Measure - 1.2 amperes

c. Energize "K102," measure -4.0 amperes

d. Energize "K103," measure -1.9 amperes

e. Energize "K104," measure -4.0 amperes

f. De-energize all relays

g. Position "LOAD CHANGE" Switch - Low

h. Measure -0.65 ampere

i. Energize "K102," measure -1.0 ampere

j. De-energize "K102"

k. Position "LOAD DISCONNECT" - down

B. Resistive Loads

These tests are made with the digital multimeter using the 20- and 200-ohm ranges. The resistances to be measured range from 1.3 to 33 ohms but measurements may be higher due to lead and relay contact resistances. All resistive loads are contained in the power resistor drawer located below the timing chassis. (See Figure 10.) Adjustments can be made to all the loads contained in this drawer. Measurements are made at the rear panel current monitor terminals.

1. 11-Volt Section

a. Position the following switches:

"11-VOLT CAL" - up

"11-VOLT LOAD DISCONNECT" - up

b. Energize "K111," measure 1.3 ohms maximum

c. De-energize "K111"

d. Energize "K109," measure 31 ohms maximum

e. De-energize "K109"

f. Short "MATCH" terminals on "TB-1"

g. Energize "K107," measure 1.8 ohms maximum

h. De-energize "K107"

i. Position "LOAD DISCONNECT" - down

2. + 30-Volt Section

a. Position the following switches:

"+ 30-VOLT C-1" - up

"+ 30-VOLT C-2" - down

b. Measure 33.0 ± 8.0 ohms

c. Position "+ 30-VOLT C-2" - up

d. Energize "K101," measure 4.75 ± 0.68 ohm

e. De-energize "K101"

f. Position "LOAD DISCONNECT" - down

3. - 30-Volt Section

a. Position the following switches:

"- 30-VOLT C-1" - up

"- 30-VOLT C-2" - down

"- 30-LOAD DISCONNECT" - up

b. Measure 16.5 ± 4.0 ohms

c. Position "LOAD DISCONNECT" - down

C. Voltage Calibration of Calibrator

These tests are made with the direct current power supply connected to the appropriate voltage monitor terminals of "TB-1". Measurements are made at the BNC jacks on the rear panel with the recording device connected. The "MAN CAL" switch is located on the front panel of the calibrator. (See Figure 9.) Typical measurements are given without a recording device connected.

1. 11-Volt Section

a.	Connect + 15 volts to the "11" terminal	15.012 V
b.	Measure output at BNC jack "V(11)"	2.567 V
c.	Turn "MAN CAL" switch on	
d.	Measure output at BNC jack "V(11)"	2.568 V
e.	Calculate voltage from power supply	15.018 V

$$V_e = \frac{V_a}{V_b} \times V_d = \frac{15.012}{2.567} \times 2.568 \tag{1}$$

2. + 30-Volt Section

a.	Connect + 40 volts to the "30" terminal	40.030 V
b.	Measure output at BNC jack "V(30)"	2.557 V
c.	Turn "MAN CAL" switch on	
d.	Measure output at BNC jack "V(30)"	2.559 V
e.	Calculate voltage from power supply	40.061 V

$$V_e = \frac{V_a}{V_b} \times V_d = \frac{40.030}{2.557} \times 2.559 \tag{2}$$

3. - 30-Volt Section

a.	Connect - 40 volts to the "-30" terminal	-40.010 V
b.	Measure output at BNC jack "V(-30)"	-2.551 V
c.	Turn "MAN CAL" switch on	
d.	Measure output at BNC jack "V(-30)"	-2.542 V
e.	Calculate voltage from power supply	-39.869 V

$$V_e = \frac{V_a}{V_b} \times V_d = \frac{-40.010}{-2.551} \times -2.542 \tag{3}$$

D. Current Calibration of Calibrator

These tests are made with the direct current power supply connected to the appropriate current monitor terminals of "TB-1." Measurements are made at the rear panel BNC jacks with the recording device connected. Typical measurements are given without a recording device connected.

1. 11-Volt Section

a. Connect + 15 volts to the "11" terminal
b. Position the following switches:

"11 VOLT CAL" switch - down
"LOAD CHANGE" switch - high
"11 LOAD DISCONNECT" - up

c. Measure current into circuit — 0.700 A
d. Measure voltage at BNC jack "I(11)" — 0.201 V
e. Calculate volts per ampere — 0.287 V/A

$$\frac{V}{A} = \frac{V_d}{A_c} = \frac{.201\ \text{V}}{.700\ \text{A}} \qquad (4)$$

f. Turn "MAN CAL" switch on
g. Measure voltage at BNC jack "I(11)" — 2.585 V
h. Calculate equivalent current — 9.007A

$$\frac{V_g}{V/A_e} = \frac{2.585\ \text{V}}{0.287\ \text{V/A}} \qquad (5)$$

i. Position "LOAD DISCONNECT" down

2. + 30-Volt Section

a. Connect + 30-volts to the "30" terminal
b. Position the following switches:

"+ 30-VOLTS C-1" - down
"+ 30-VOLTS C-2" - up
"30 LOAD DISCONNECT" - up
"LOAD CHANGE" Switch - high

c. Energize relay "K102"
d. Measure current into circuit — 4.022 A
e. Measure voltage at BNC jack "I(30)" — 1.209 V
f. Calculate volts per ampere — 0.301 V/A

$$\frac{V}{A} = \frac{V_e}{A_d} = \frac{1.209\ \text{V}}{4.022\ \text{A}} \qquad (6)$$

g. Turn "MAN CAL" switch on
h. Measure voltage at BNC jack "I(30)" — 2.590 V
i. Calculate equivalent current — 8.605 A

$$\frac{V_h}{V/A_f} = \frac{2.590\ \text{V}}{0.301\ \text{V/A}} \qquad (7)$$

j. De-energize relay "K102"
k. Position "LOAD DISCONNECT" down

3. - 30-Volt Section

a. Connect - 30 volts to the "- 30" terminal
b. Position the following switches:

"- 30-VOLT C-1" - down
"- 30-VOLT C-2" - up
" LOAD CHANGE" switch - high
"- 30 LOAD DISCONNECT" - up

c. Energize relay "K102"
d. Measure current into circuit — -4.068A
e. Measure voltage at BNC jack "I(-30)" — -1.162V
f. Calculate volts per ampere — 0.286V/A

$$\frac{V}{A} = \frac{V_e}{A_d} = \frac{-1.162V}{-4.068A} \tag{8}$$

g. Turn "MAN CAL" switch on
h. Measure voltage at BNC jack "I(-30)" — -2.594V
i. Calculate equivalent current — -9.070A

$$\frac{V_h}{V/A_f} = \frac{-2.594V}{0.286V/A} \tag{9}$$

j. De-energize relay "K102"
k. Position "LOAD DISCONNECT" down

4. Leakage Current Section

a. Connect a low voltage, current limited to 1.0 ampere, between one of the "M" terminals and the "C" (common) terminal.
b. Energize relay "K106"
c. Measure current into circuit — 1.000A
d. Measure voltage at BNC jack "I(LK)" — 2.596V
e. Calculate volts per ampere — 2.596V/A

$$\frac{V}{A} = \frac{V_d}{A_c} = \frac{2.596V}{1.000A} \tag{10}$$

f. Turn "MAN CAL" switch on
g. Measure voltage at BNC jack "I(LK)" — 2.591V
h. Calculate equivalent current — 0.998A

$$\frac{V_g}{V/A_e} = \frac{2.591V}{2.596V/A} \tag{11}$$

i. De-energize relay "K106"

E. Noise Voltage Calibration

These tests are made with the Function Generator connected to the appropriate voltage monitor terminals of "TB-1". The output of the Function Generator is setup for a sine wave mode with an amplitude of 420 millivolts peak-to-peak (Vpp) and a frequency of 500 Hz. Measurements are made at the rear panel BNC jacks with the recording device connected. Typical measurements are given without a recording device connected. Note: A.C.

voltage measurements displayed by the Digital Multimeter are in RMS units. These measurements were converted to Vpp peak-to-peak by multiplying by $2\sqrt{2}$.

$$Vpp = 2\sqrt{2}\ V_{RMS} \tag{12}$$

The calibrator output is a D.C. voltage which is equivalent to volts peak (V_p) = $\frac{1}{2}$ Vpp.

1. <u>11-Volt Section</u>

a. Connect 420 mVpp to the "11" terminal — <u>0.415Vpp</u>

b. Measure A.C. voltage at BNC jack "N(11)" — <u>2.569Vpp</u>

c. Calculate the amplifier gain — <u>6.190</u>

$$G = \frac{V_b}{V_a} = \frac{2.569Vpp}{0.415Vpp} \tag{13}$$

d. Turn "MAN CAL" switch on

e. Measure DC voltage at BNC jack "N(11)" — <u>1.280V</u>

f. Calculate equivalent millivolt input — <u>207mV</u>

$$\frac{V_e}{Gain_c} = \frac{1.280V}{6.190} \tag{14}$$

2. <u>+30-Volt Section</u>

a. Connect 420 mVpp to the "30" terminal — <u>0.420Vpp</u>

b. Measure A.C. voltage at BNC jack "N(30)" — <u>2.604Vpp</u>

c. Calculate amplifier gain — <u>6.200</u>

$$G = \frac{V_b}{V_a} = \frac{2.604Vpp}{0.420Vpp} \tag{15}$$

d. Turn "MAN CAL" switch on

e. Measure D.C. voltage at BNC jack "N(30)" — <u>1.273V</u>

f. Calculate equivalent millivolt input — <u>205mV</u>

$$\frac{V_e}{Gain_c} = \frac{1.273V}{6.200} \tag{16}$$

3. <u>-30-Volt Section</u>

a. Connect 420 mVpp to the "-30" terminal — <u>0.421Vpp</u>

b. Measure A.C. voltage at BNC jack "N(-30)" — <u>2.603Vpp</u>

c. Calculate amplifier gain — <u>6.183</u>

$$G = \frac{V_b}{V_a} = \frac{2.603Vpp}{0.421Vpp} \tag{17}$$

d. Turn "MAN CAL" switch on

e. Measure D.C. voltage at BNC jack "N(-30)" — <u>1.280V</u>

f. Calculate equivalent millivolt input — <u>207mV</u>

$$\frac{V_e}{Gain_c} = \frac{1.280V}{6.183} \tag{18}$$

IV. TEST PROCEDURES

The battery tests using the procedures of this section are made with the following list of equipment:

- Battery Tester
- A shock tester that can be triggered by a relay contact closure.
- A piezoelectric accelerometer and charge amplifier for measuring the shock pulse.
- A multiple channel instrumentation tape recorder (i.e. Honeywell Model 101).
- Digital Multimeter, Hewlett-Packard Model 3466A.

Reference is made to Figure 12 for interconnecting the listed equipment.

A. Pretest Procedures

1. Position the following switches on the Battery Tester:

a. All relay manual energizing switches on the rear panel should be in their center-off position so all relays are de-energized.
b. All Cal switches on the rear panel - down
c. "MAN CAL" switch on Calibrator - down
d. All "LOAD DISCONNECT" switches - down.

2. Select "HIGH" or "LOW" load on front panel

3. Connect all BNC monitor outputs to the tape recorder. FM Wideband-I electronic record amplifiers should be used. A tape speed of 7 1/2 inches per second is adequate for the test. This will provide a data input frequency response from DC to 5 kHz. All inputs to the record amplifiers should be adjusted for a nominal ± 1.414 volts peak-to-peak (1.0 volts RMS) input level. Also the record amplifier inputs must be offset according to the following chart:

Data	Offset	Data	Offset
"V(11)"	Neg (-1.4 Volts)	"I(-30)"	Pos.
"V(30)"	Neg	"N(11)"	0 (No Offset)
"V(-30)"	Pos (+1.4 Volts)	"N(30)"	0
"I(11)"	Neg	"N(-30)"	0
"I(30)"	Neg	"I(LK)"	Neg

These offsets can be accomplished by changing jumpers on the record amplifier card of the tape recorder.

4. Connect Battery Tester to a 115-Volt, 60- Hertz power source.

a. Turn on "AC POWER" switch.
b. Turn on three timer "POWER SUPPLY" switches.
Note: When the "POWER SUPPLY +5, +5" switch is turned on, some of the timers will function due to turn-on transients. All timers will be off or in a normal state after 100 seconds.

5. Mount and connect accelerometer and associated charge amplifier.

a. Calculate appropriate calibration voltage for the charge amplifier. The following example is given:

$$S = 1.6\ \frac{pC}{g} \quad \text{(Accelerometer Sensitivity)} \tag{19}$$

g = 1000 g's (Acceleration level)

c = 1000 pF (Calibration Capacitor)

q = S x g = 1600 pC (charge)

$$V = \frac{q}{c} = \frac{1600}{1000} = 1.6 \text{ Volts} \tag{20}$$

b. Turn "MAN CAL" switch on the front of the calibrator to on.
c. Adjust the calibration output voltage. (Measure output at BNC jack on rear panel.)
d. Turn "MAN CAL" switch to off.
e. Connect "CAL VOLTS" output to the charge amplifier calibration input.

6. Connect voltage monitor and current monitor leads to the test battery.

7. Connect shock table trigger leads to the shock table terminals on the rear of the battery tester.

B. Procedures During Test

1. Reset "ELAPSED TIMER" on Battery Tester.
2. Position 3 "LOAD DISCONNECT" switches - up.
3. Condition shock table to be triggered for test.
4. Start tape recorder.
5. When tape recorder is up to speed, push ""START"" button on calibrator.
6. The following sequence of events will occur:

a. Calibrate on for 50 or 500 milliseconds
b. Shock table is triggered
c. The output voltage of the 11-volt section of the test battery exceeds 10 volts.
d. The following timing sequence starts. (Time of each event can be noted on the elapsed timer.)

0 - "LOCKOUT" LED - on
"GATE" LED - on
"5.2 LOAD CHG" LED - on
"10 LOAD CHG" LED - on
"1.5" LED - on
"45" LED - on
"M" LED - on
210 ms - "M" LED - off
"LK" LED - on
1 sec. - "SQB" LED - on (20 ms)

1.5 sec. - "1.5" LED - off
2 sec - "SQB" LED - on (20 ms)
3 sec - "SQB" LED - on (20 ms)
4 sec - "SQB" LED - on (20 ms)
4.2 sec - "GATE" LED - off
5 sec - "SQB" LED - on (20 ms)
5.2 sec - "5.2 LOAD CHG" LED - off
10 sec - "10 LOAD CHG" LED - off
29.5 sec - "4A LOAD" LED - on (500 ms)
39.5 sec - "4A LOAD" LED - on (500 ms)
45 sec - "45" LED - off
49.5 sec - "4A LOAD" LED - on (500 ms)
70 sec - End of ± 30-volt test
100 sec - "LOCKOUT" LED - off
"LK" LED - off
End of 11-volt test

C. Procedures After Test

1. Position "LOAD DISCONNECT" Switches - down
2. Stop elapsed timer
3. Stop tape recorder.

V. CONCLUSION

After the design and assembly of the Battery Tester was completed, performance tests were made on the unit. All test requirements as stated in MIL-P-63235(AR) were satisfactorily met.

APPENDIX A

SUPPLEMENTAL DIAGRAMS

The following 11 diagrams will aid in troubleshooting any of the circuits contained in the battery tester.

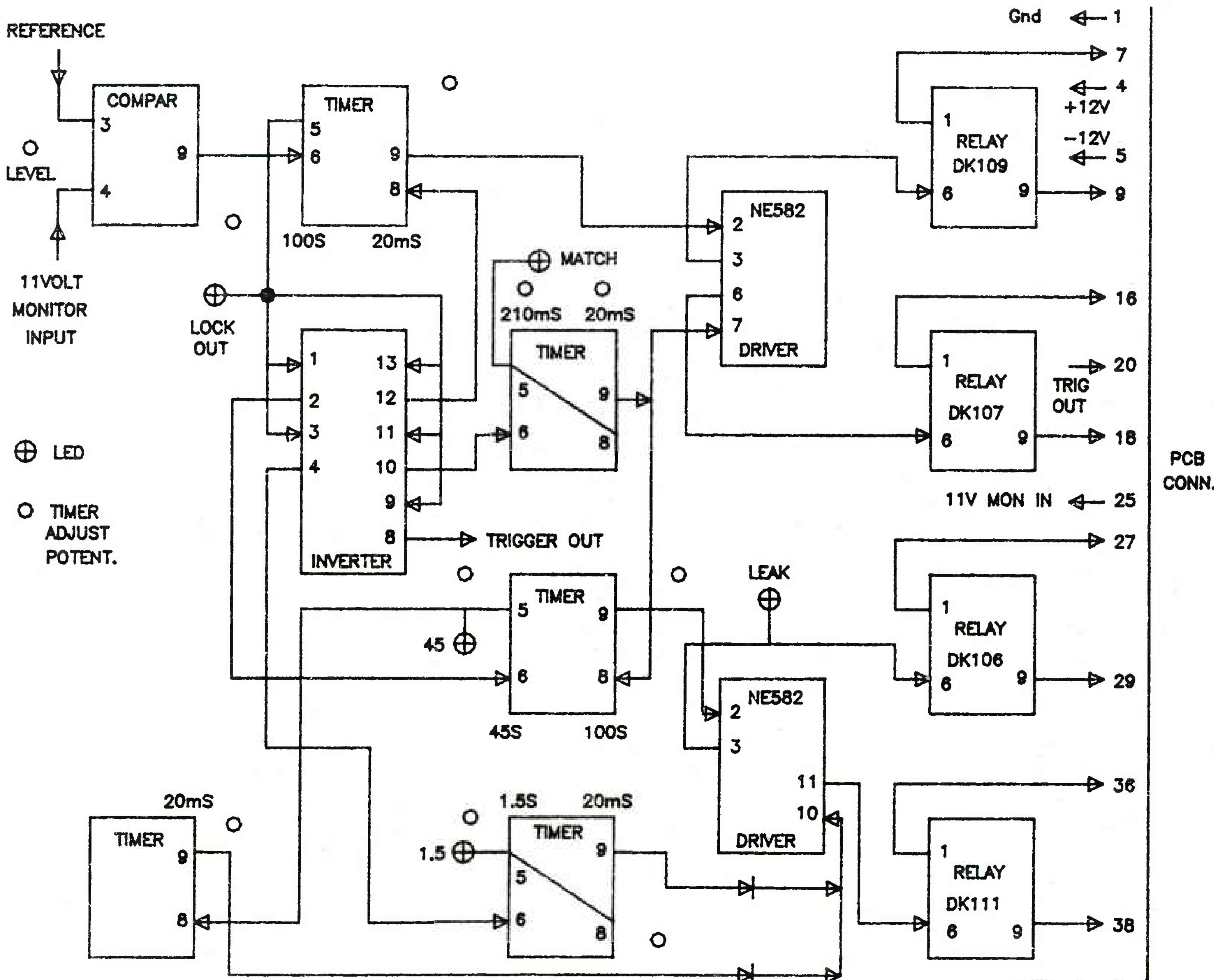


Figure A-1. 11-Volt Timer Diagram

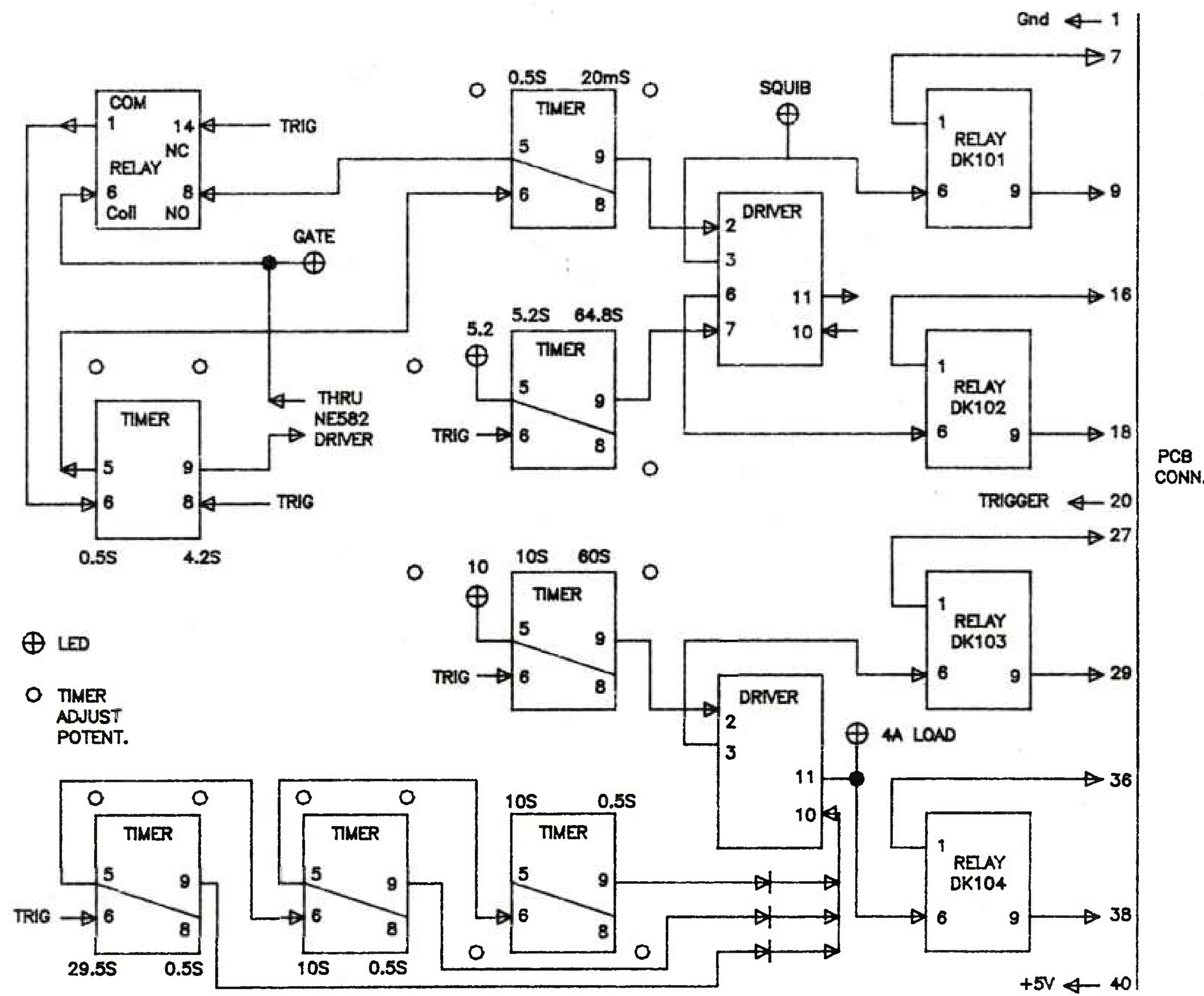


Figure A-2. 30-Volt Timer Diagram

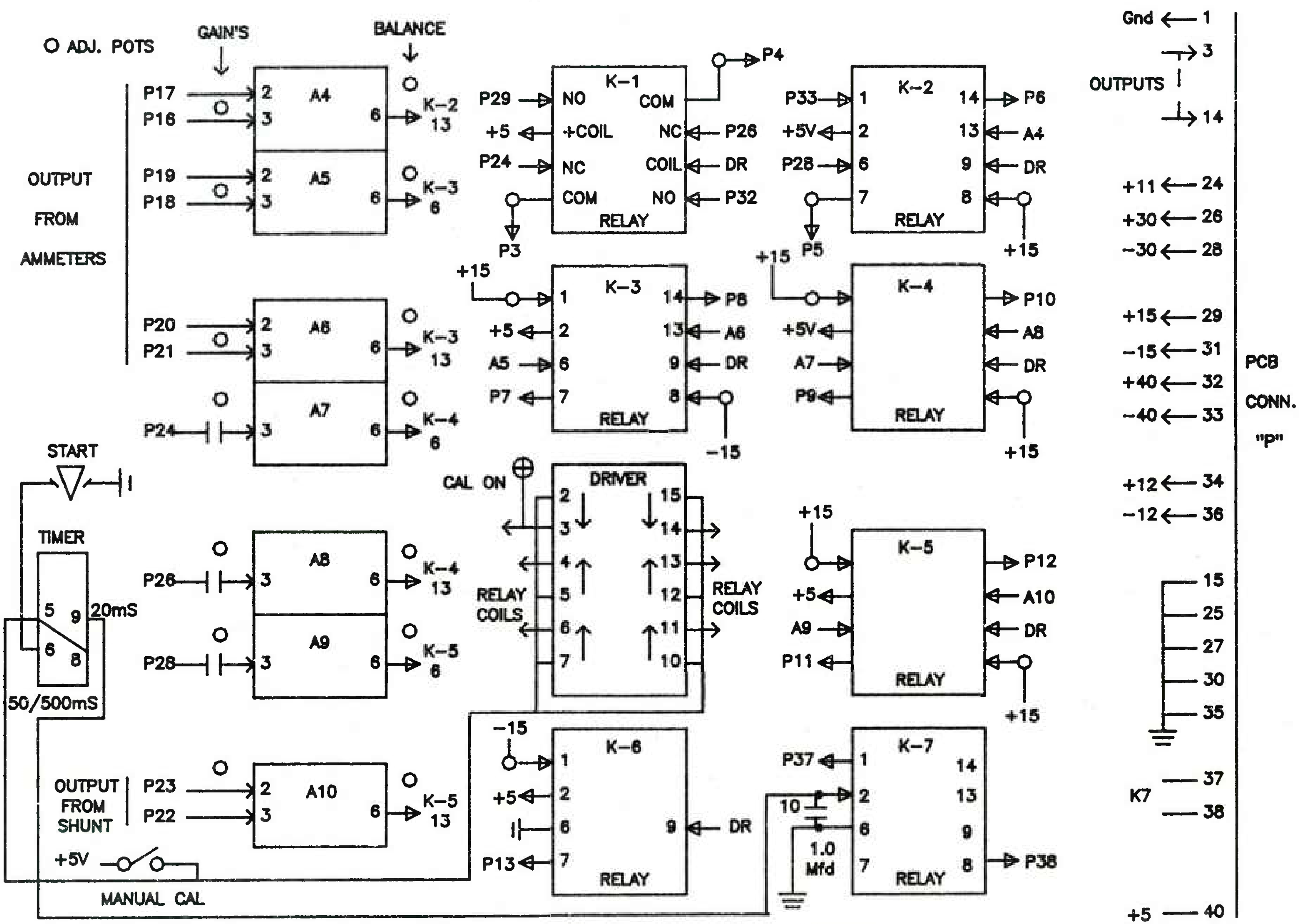
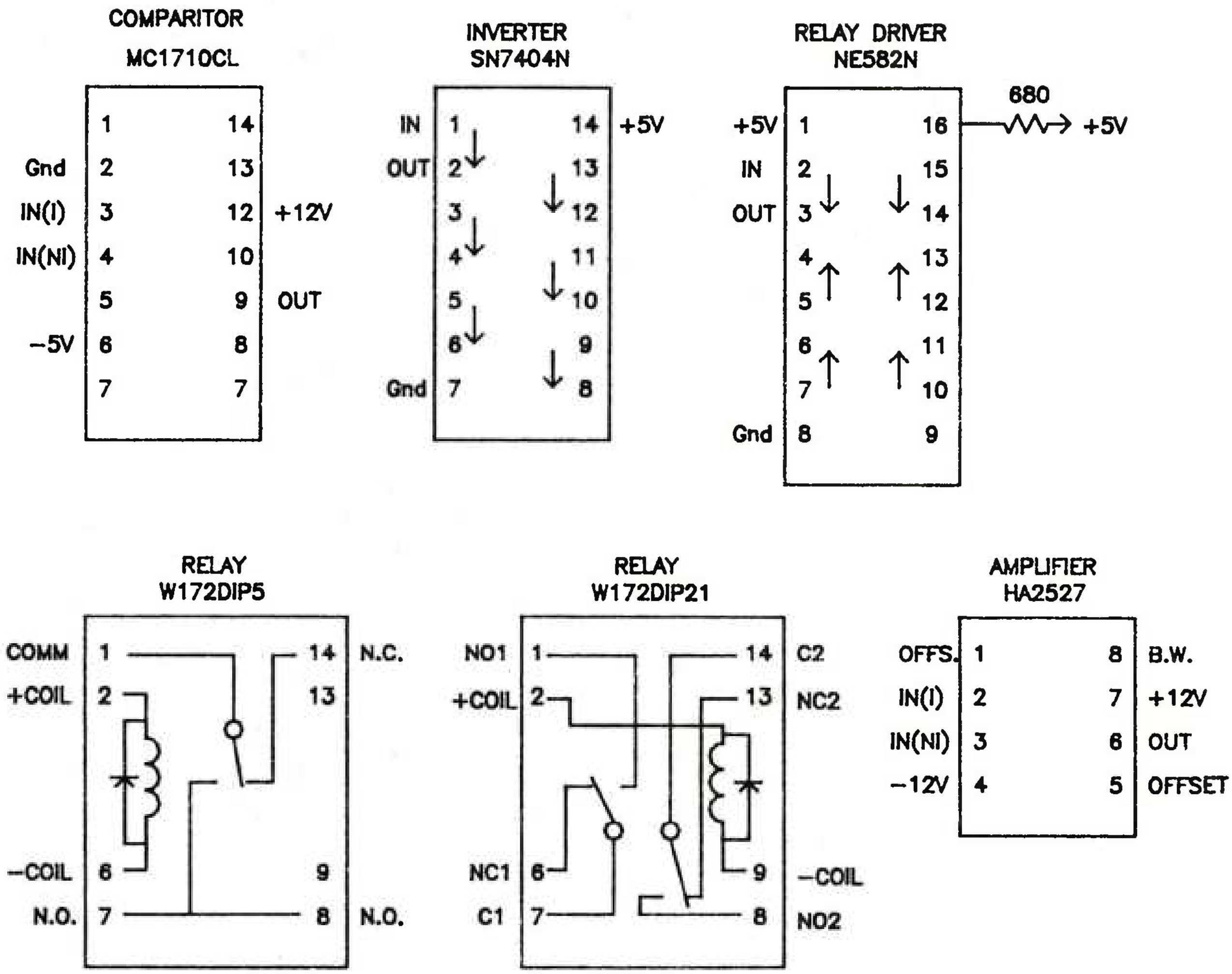
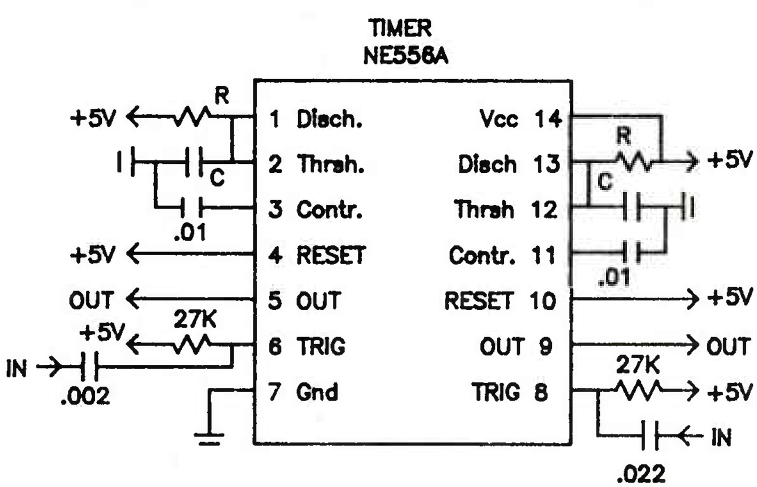


Figure A-3. Calibrator and Amplifier Diagram





TIMING COMPONENTS

TIME	C(Mfd)	R
20mS	.22	62K
50mS	1	33K
210mS	5	28K
500mS	5	65K
1.5S	25	40K
4.2S	10	280K
5.2S	10	347K
10S	10	622K
29.5S	25	788K
45S	50	600K
60S	50	800K
64.8S	100	432K
100S	100	667K

Figure A-4. Integrated Circuit Diagrams

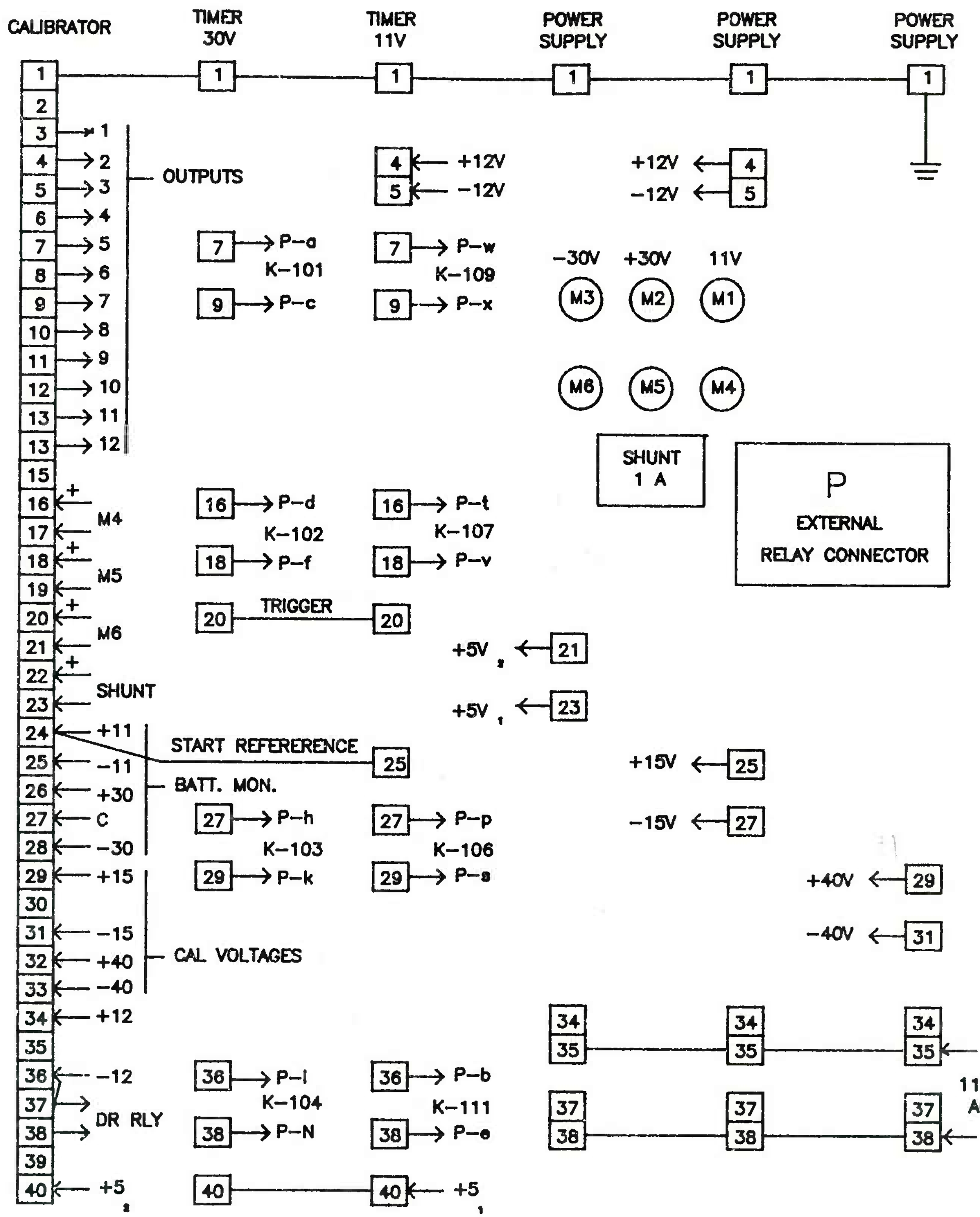


Figure A-5. PC Board Interconnections

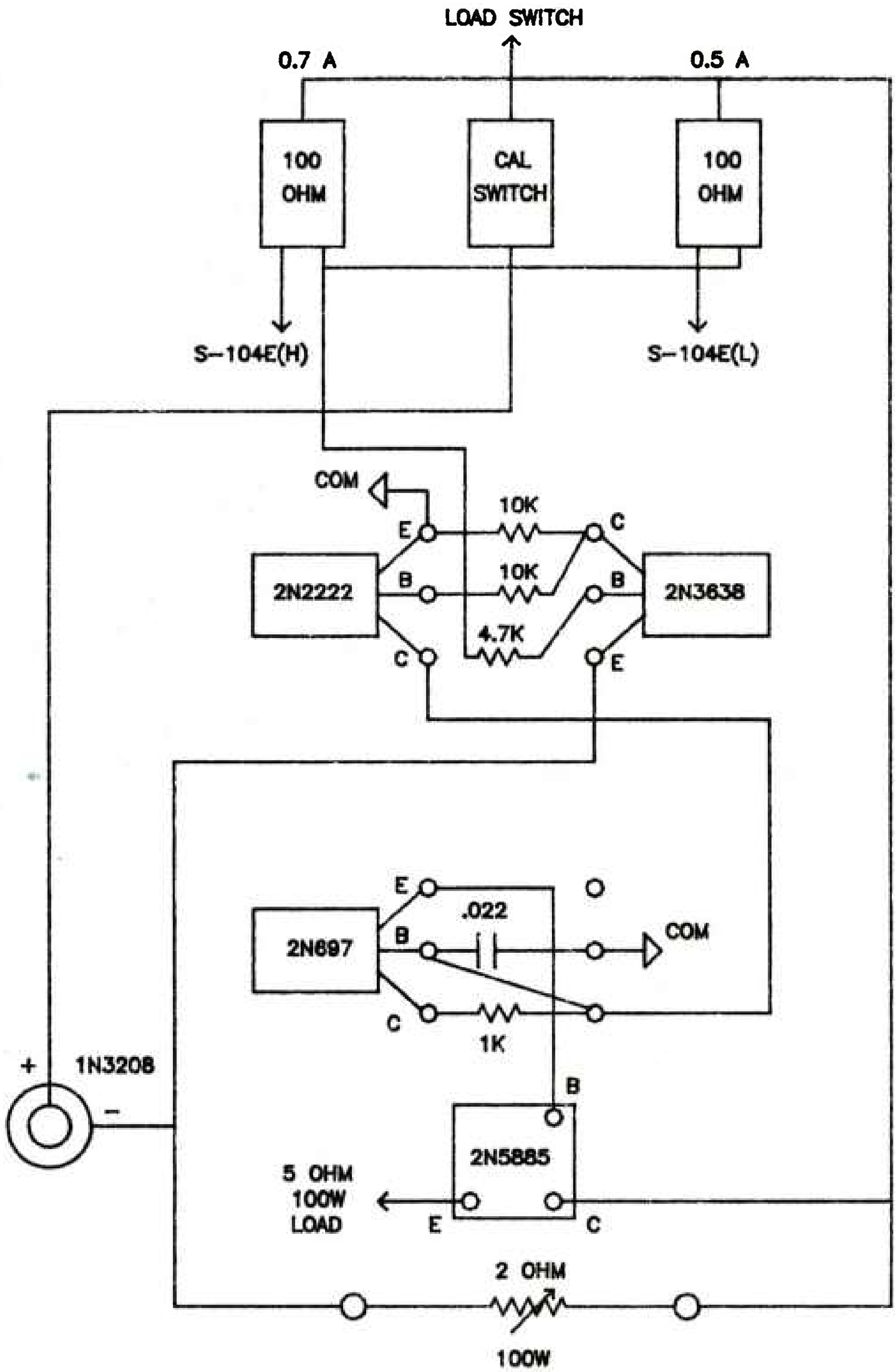


Figure A-6. 11-Volt Constant Current Load

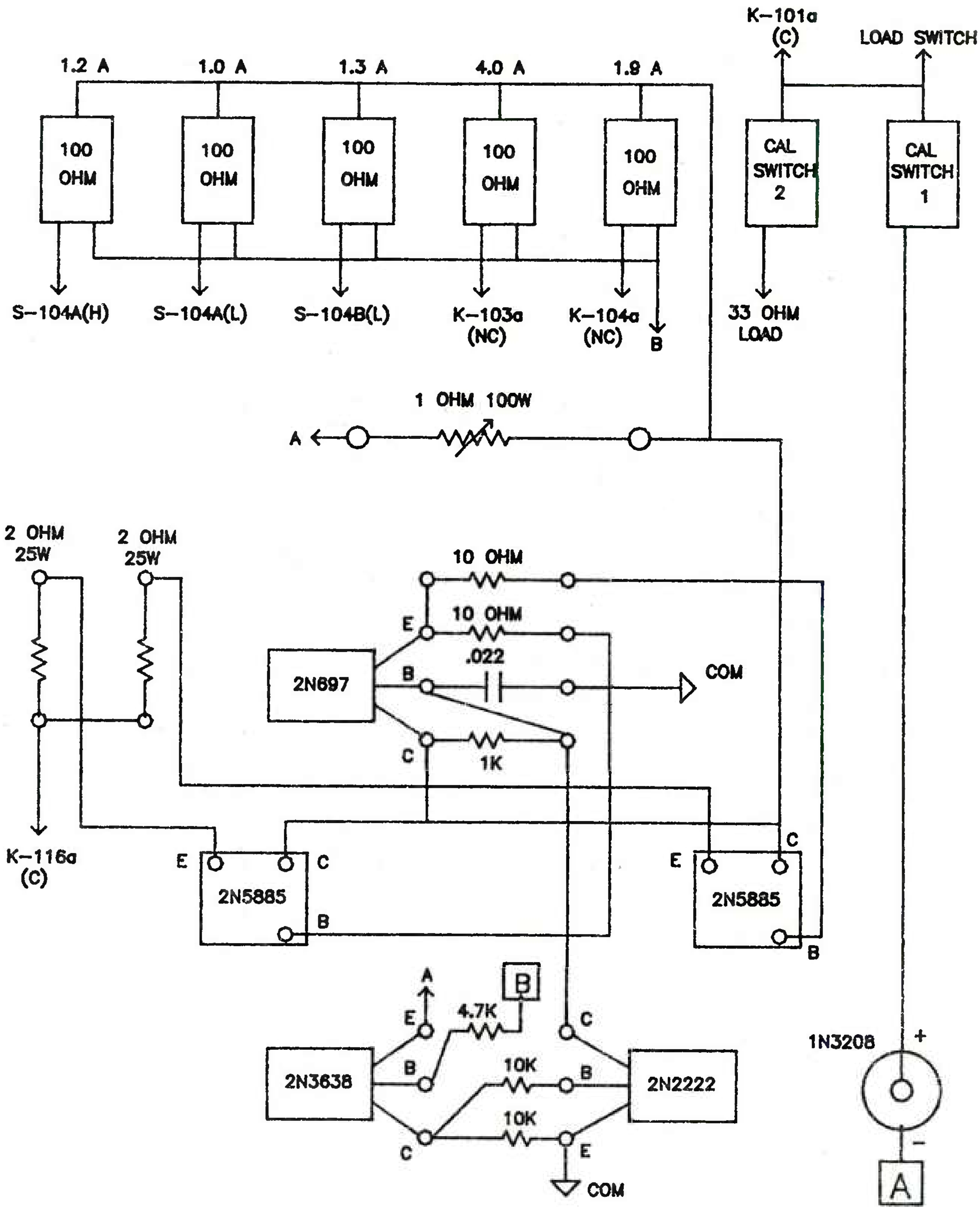


Figure A-7. +30-Volt Constant Current Load

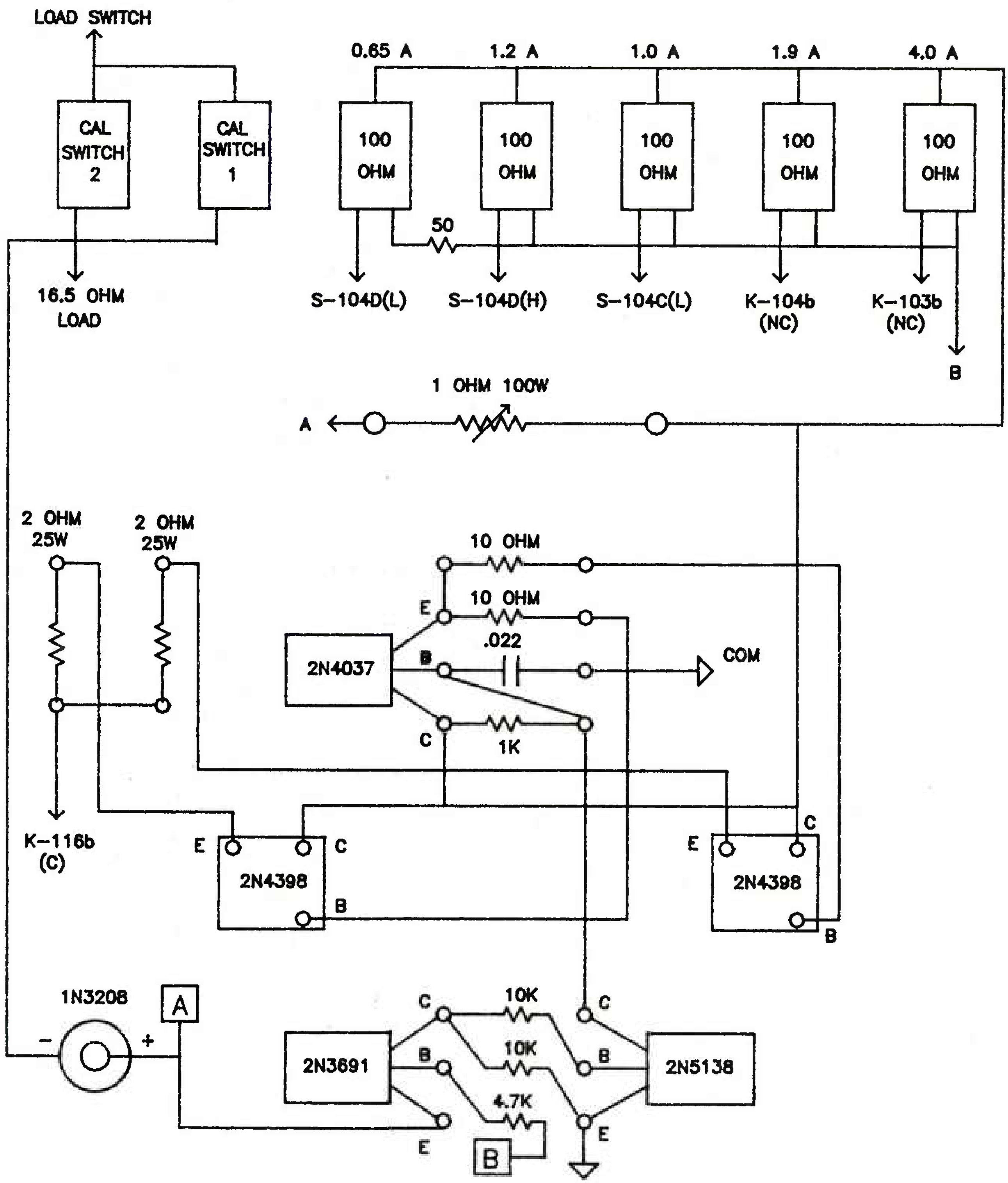


Figure A-8. -30-Volt Constant Current Load

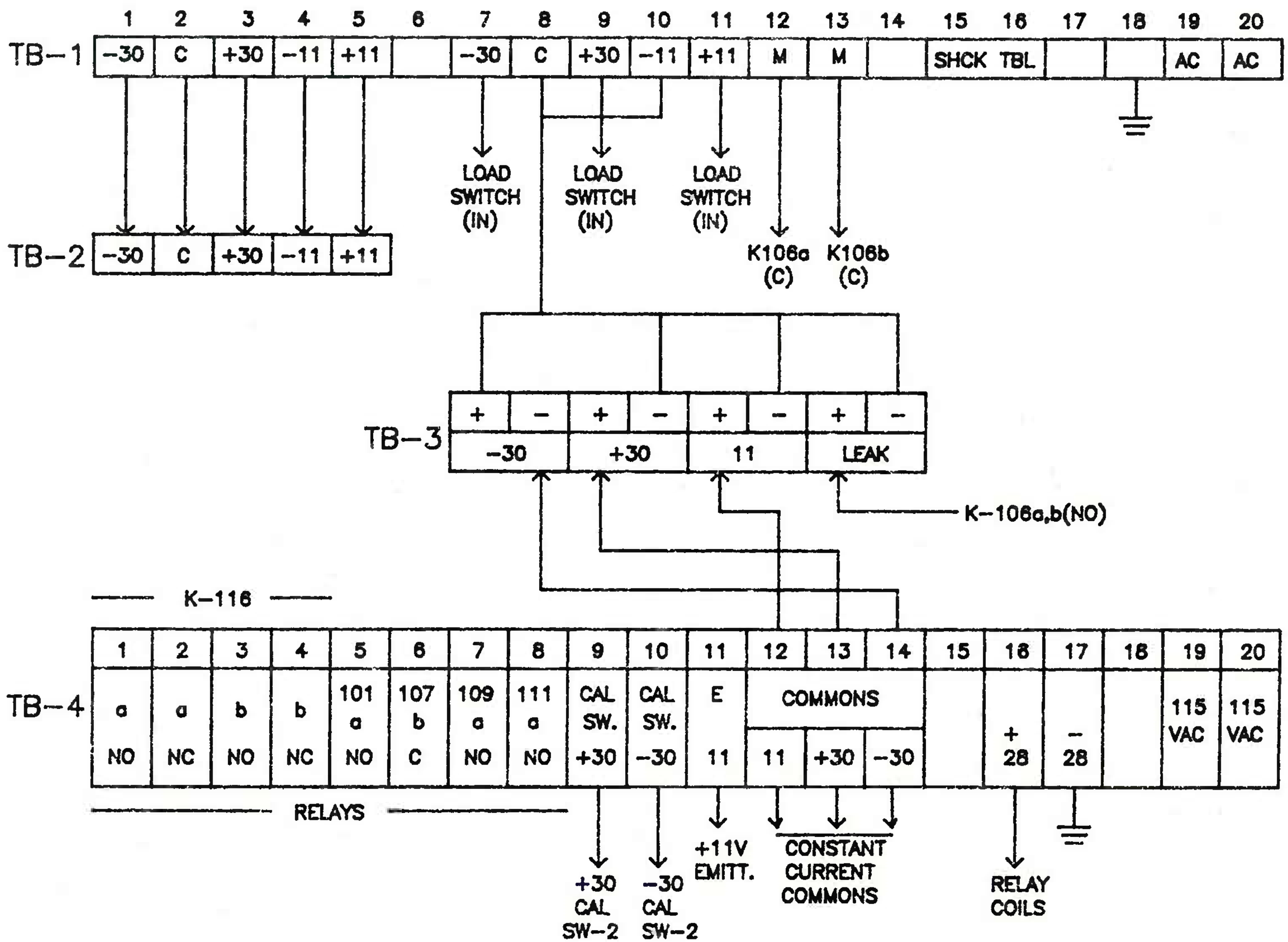


Figure A-9. Interconnection Diagram 1

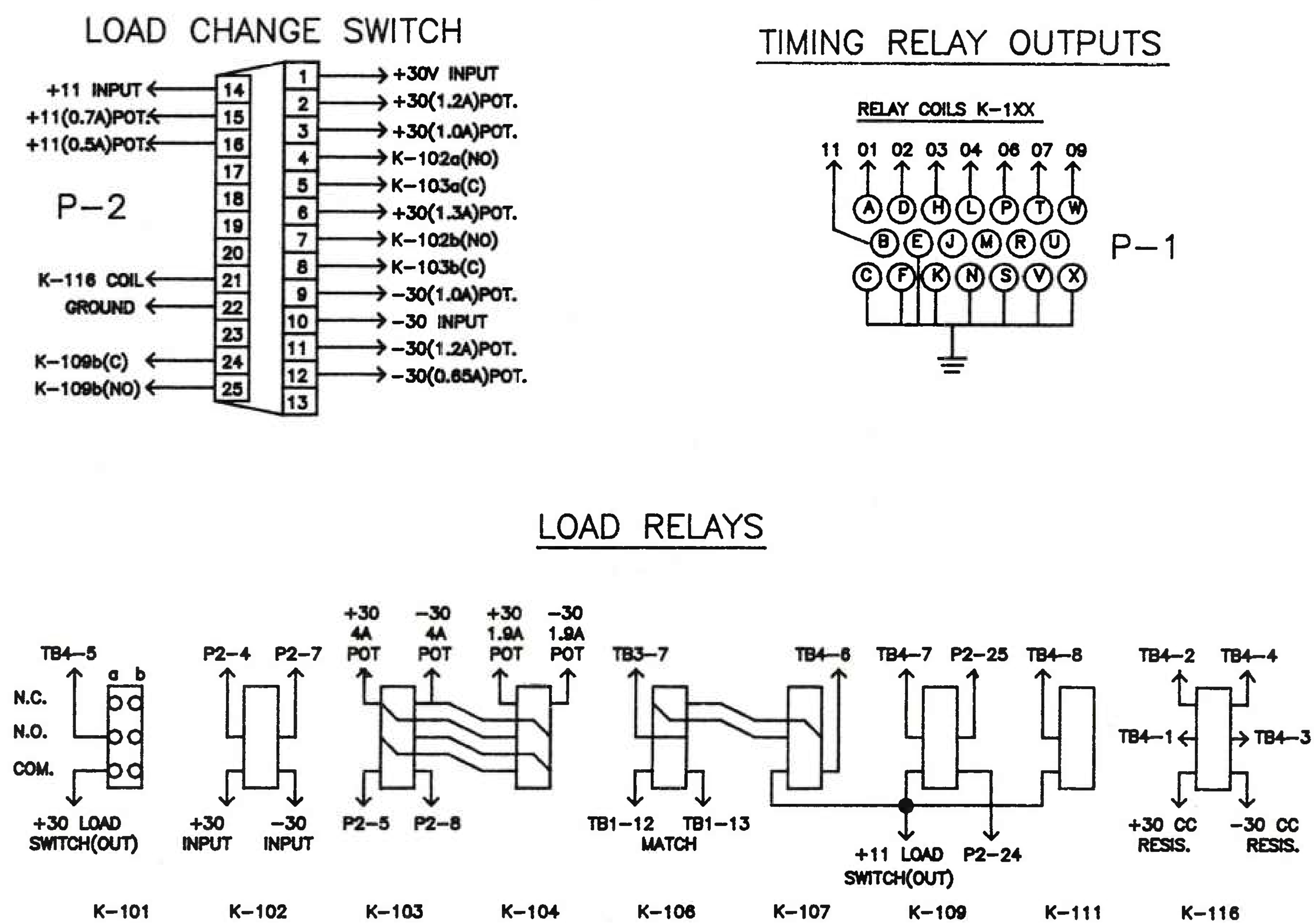


Figure A-10. Interconnection Diagram 2

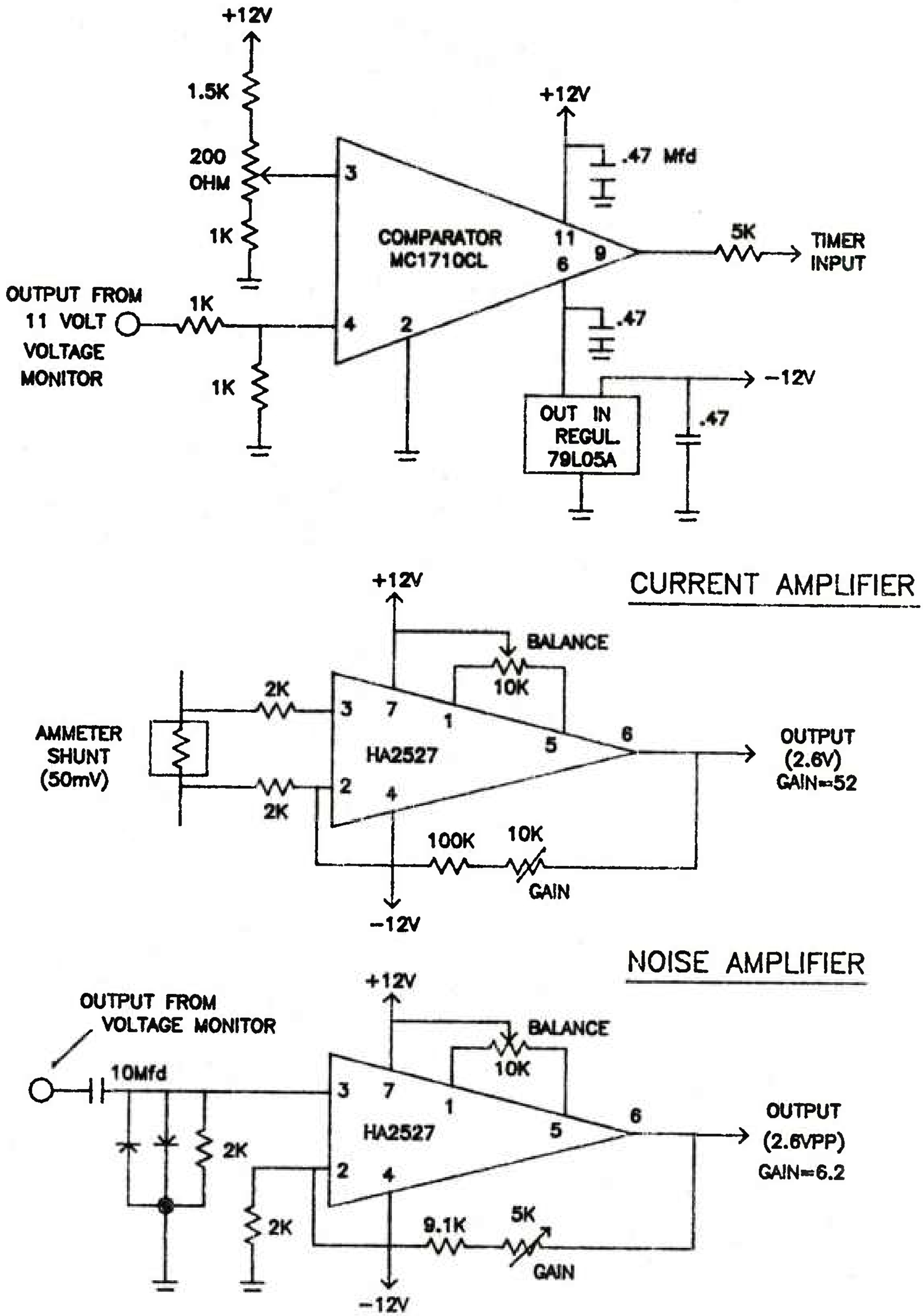


Figure A-11. Comparator and Amplifier Circuits

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